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THE TREATMENT OF FRACTURES OF THE HUMERUS BY SUSPENSION AND TRACTION.

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The treatment of fractures of the humerus to be described was devised in 1914 in the Ambulance of the American Hospital of Paris, at Neuilly.

At first used to combat the swelling of the arm, forearm and hand so common in infected gun-shot fractures of the arm, its advantages in facilitating dressings and the very good reductions and early unions obtained, brought it into general employment for all fractures of the humerus, simple as well as gunshot. The chief objection to it has been the confinement of the patient to bed. This objection is valid in war only when the patient is treated in hospitals where evacuation of the wounded is necessary. The answer is that the very transportability of the wounded suffering from these fractures makes it possible to send them at once after being wounded to base hospitals in quiet zones which do not have to be evacuated. In such hospitals there is no objection to placing the patient in an apparatus unfit for transportation, and the more rapid union and earlier restoration of function obtained by the suspension treatment more than justify its employment.

In uninfected gunshot fractures we repeatedly observed union within twenty days and the patients were using their arms within thirty days. In civil practice we have found that union has been obtained and the suspension treatment discontinued, at least during the day, in an average of four weeks. I say "during the day" for it is desirable, if the patient uses a sling when up, to suspend the arm at night until he has full use of it.

The treatment is easy to apply to fractures of the humerus, not requiring nearly so much skill as does treatment by splints. No splints are used. Immobilization is achieved by traction aided to a certain extent by the way in which the limb is suspended. Although the fragments are efficiently immobilized one upon the other yet motion is permitted at both the shoulder and the elbow. These joints, continually moving, never become stiffened, which explains the good functional results obtained.

For suspension some sort of frame is necessary. The so called Balkan frame is excellent but a gallows frame consisting of a post and arm is sufficient. When the later is used, the post should be set above (anatomically speaking) and as near the head of the patient as possible, and the arm should correspond in direction to that in which traction is made so that the patient's arm can hang directly below it.

When using the Balkan frame, as the overhead bars to which the arm is suspended usually correspond to the long axis of the bed and not to that of the fractured limb, two bars should be used, one directly over the center of the arm, the other a few inches outside of it, so as to be vertically over the hand. A pulley should then be fixed to each of the bars at the points mentioned, namely one over the center of the arm, the other over the hand. Other pulleys should be fastened to the bars either at the head or the foot of the bed so that the weights attached to the suspension cords may be out of the way of the patient and attendants. The patient being in the bed, the limb is uncovered and the traction and suspension bands are applied.

These bands or straps may be made of Canton flannel or gauze to be glued onto the skin, of diachylon adhesive plaster or of ordinary Z. O. rubber plaster. One of the former is best, for the latter is apt to slip gradually. Still it can be frequently changed and, for the light work that is necessary in fractures of the humerus, will generally suffice.

The traction bands are applied to the inner and outer surfaces of the arm and their ends, narrowed to enter buckles, should extend for four inches below the elbow when the latter is flexed. They may extend a couple of inches above the fracture.

The suspension bands are applied to the flexor and extensor surfaces of the forearm, from the elbow to just above the wrist. Their ends, narrowed to enter buckles, should reach to the tips of the fingers.

A sling should be prepared for the arm. This is made of heavy muslin or duck; or, in case of a compound fracture necessitating wet dressings, of rubber sheeting. Its width should correspond to the length of the upper arm, that is about eight inches, and it should be about twenty inches long. Its ends are fastened to a stick which acts as a spreader, to

the ends of which the suspension cord for the arm is attached by means of a bridle.

It now remains to fasten the traction bands on the arm and the suspension bands on the forearm to their respective cords. The traction bands are buckled to a spreader of wood two inches wide and four inches long. These spreaders are kept in stock and may be used for the arm or leg. Through the center of the spreader a hole is bored through which the traction cord is passed and fastened by means of a topsail halyard knot. A piece of tape six inches long with a buckle sewed to each end is fastened to the spreader by tacks. The buckles therefore overhang the ends of the spreader by about an inch and when the traction bands are buckled the spreader will be about four inches from the elbow.

The spreader for the forearm suspension is mounted with tape and buckles in a similar manner but it is four and one-half inches square and, in addition to the tape, a piece of elastic webbing three-quarters of an inch wide and twelve inches long is passed over the spreader at right angles to the tape. The ends of the webbing thus lap over the sides of the spreader nearly four inches on either side. To each end of the webbing a round piece of wood (part of a broomhandle does very well), four and one-half inches long is fastened by a nail or strong tack. This piece of wood serves as a handle or hand-rest for the patient to grasp and exercise the fingers.

The arm is now suspended, using, as a rule, equal weights for both arm and forearm. Three pounds on each is an average weight. The traction should be about eight pounds at first for the average arm, which is diminished to four or five pounds as soon as reduction is obtained. Much more may be necessary for very muscular arms.

In all fractures, except those of the surgical neck in which the proximal fragment may assume a position of exaggerated abduction and outward rotation, the arm lies in a sling in a horizontal position and the forearm in a vertical position, the elbow being flexed to 90 degrees. In supracondylar fractures the lower fragment is apt to flex itself sharply so that there is an angular deformity forward at the fracture. This may be overcome by flexing the elbow to less than 90 degrees, which is done by moving the suspension pulley for the forearm toward the head of the bed.

Bowing forward is also corrected by increasing the suspension weights on the forearm and diminishing that on the arm. Bowing backward is corrected by the opposite, i. e., increasing the arm weight and decreasing the forearm weight.

In low fractures the direction in which traction is made is of little importance for the stretched muscles about the long proximal fragment keep it in line with the distal fragment. In fractures at the upper part of the shaft, particularly those above the insertion of the pectoralis major, the proximal fragment takes a position of extreme abduction and as it is impossible to control its position, the distal fragment

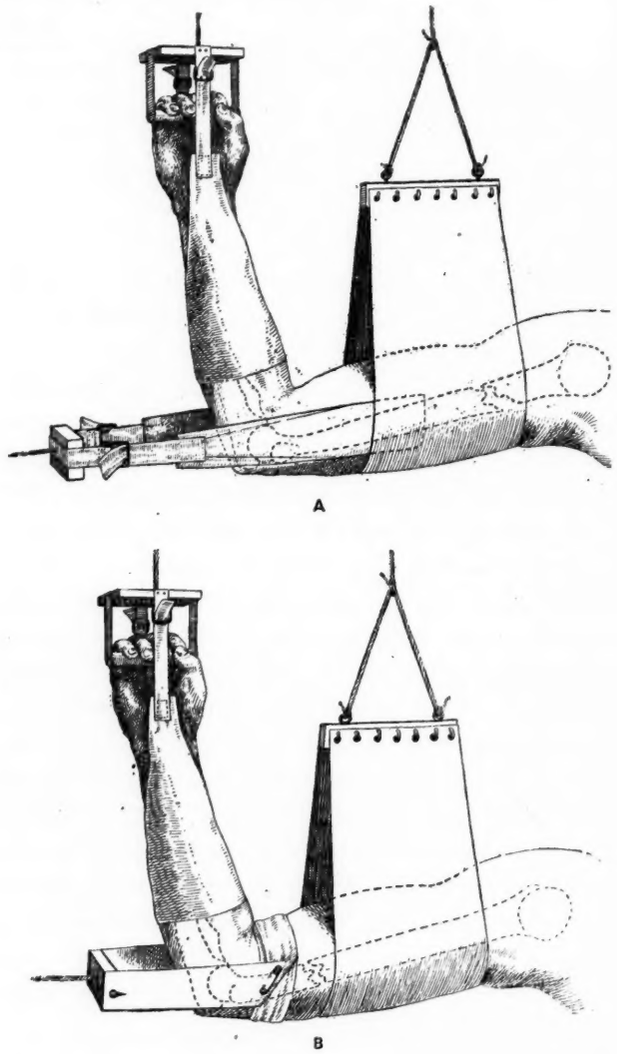

Fig. 1. Detail of Method of Suspension and Traction for Fracture of the Humerus.

Suspension of forearm is made by bands glued to skin and which are attached by straps and buckles to a wooden spreader. A round wooden handle is attached by pieces of elastic webbing to ends of spreader, thus enabling patient to exercise the fingers. The arm is suspended by a sling of duck, muslin or rubber sheeting, one end of which is tacked to one side of a wooden spreader; the other end is pierced with eyelets which hook over hooks on the other side of the spreader, so that the sling can be reduced for dressings. Traction in case of high fracture (A) is made by bands glued to the skin of the arm and attached by buckles and straps to a wooden spreader. In low fractures (B) by doubled band of muslin 6 cm. wide fastened as shown about the padded arm just above the elbow. The padding under the band has been omitted in the drawing for the sake of clearness. In practice the Dakin pad over the wound suffices. Screw heads on the ends of the spreader button into holes in the ends of the band. (From Keen's Surgery, Vol. VII. Courtesy of W. B. Saunders Co.)

must be brought into line with it; consequently, as traction must be made in this line, the pulley over which the traction cord runs must be placed at right angles to the bed and in some fractures of the surgical neck even as much as 130 degrees from the line passing from the shoulder to the foot of the bed. In fractures above the insertion of the pectoralis major and latissimus dorsi, the proximal fragment is also rotated outward so that the distal fragment must be rotated correspondingly. This is accomplished, the patient being in the recumbent posi-

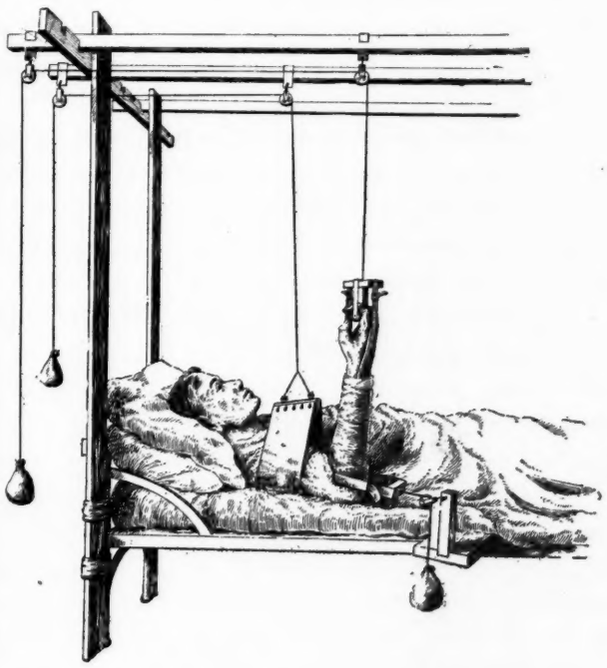

Fig. 2. Method of Installing Traction with Suspension for Fractures of the Humerus.

In this instance traction is made by bands glued to the arm and buckled to a spreader. The pulley for the traction cord is attached to the abduction board; the amount of abduction being adjusted by slipping the board in or out under the mattress. Note the arrangement for suspension, the hand and forearm being suspended in a plane lateral to that in which the arm is suspended. (From Keen's Surgery, Vol. VII. Courtesy of W. B. Saunders Co.)

tion and the forearm flexed to 90 degrees, by keeping the suspension pulley for the forearm in the vertical plane passing through the humerus and traction pulley until the direction of traction passes the angle of 90 degrees with the body. As the angle of traction has to be increased beyond this point it will be found the rotation outward must be increased also, so that in the extreme position of abduction and rotation out the arm and flexed forearm come to lie in the coronal plane.

The angle in which traction must be made to correct deformity, is determined by repeated *x*-ray examinations and, as the patient is in bed, a portable apparatus is necessary. It is important that the pulley over which the traction cord passes should be as far as possible from the elbow, because if close to the elbow movements of the patient will change the angle of traction to a marked degree. The pulley is the center of the circle and the traction cord the radius while the patient moves in the circumference, and therefore to prevent undue angulation the radius and circle should be as large as possible.

For low fractures the pulley may be put at the foot of the bed, but in higher fractures in which abduction is necessary some form of outrigger is neces-

Fig. 3. Method of Treating Fractures of the Surgical Neck of the Humerus.

Note the marked abduction and rotation out necessary to bring the distal in line with the proximal fragment. (From Keen's Surgery, Vol. VII. Courtesy of W. B. Saunders Co.)

sary. For abduction up to 90 degrees a board six to eight inches wide and about six feet long may be slipped across the bed under the mattress where it is held by friction, no other fastening being necessary. At the outer end of the board an upright about fifteen inches high is fixed, to which the traction pulley is fastened. By changing the direction of the board the proper angle of traction is obtained easily. For abduction greater than 90 degrees an outrigger is fastened across the headframe of the Balkan frame and the traction pulley attached to it. In these cases the suspension cord for the forearm passes over a pulley fixed to the headframe in order to obtain the necessary rotation out.

In all fractures treated by suspension and traction, motion is constantly occurring at the shoulder, from the patient's movements in bed. The patient should

also be encouraged to move the elbow, and the extent of motion should be gradually increased as consolidation progresses, so that when union is complete the motions of the articulations should be normal. At first the patient must be aided in making these motions by steadying the arm. While motion takes place at both shoulder and elbow the patients have no pain, proving that fixation at the point of fracture is good.

Fractures of the diaphysis may be treated by fixation in splints and the motions of the shoulder and elbow recovered after a period of physiotherapy, but we are all familiar with the disagreeable ankyloses following the splint treatment of fractures close to or entering the shoulder or elbow. Because of the constant motion taking place in the joints in the treatment by suspension no ankylosis need be feared, particularly if motions are systematically made.

One of the chief objections to fixation by splinting is the faulty reduction of rotary deformity in high fractures. The aeroplane splint, while correcting angular, does not provide for rotary deformity and in fact exaggerates it, so that many patients treated by this splint cannot move the hand away from the body when the elbow is flexed. To correct it with the aeroplane splint the elbow would have to be extended and the arm rotated out, or with the elbow flexed the hand would have to be carried above the patient's head.

The earlier union obtained by the suspension treatment can be explained by better fixation, but perhaps the chief cause is better nutrition due to maintenance of function and normal circulation.

POST-GRADUATE MEDICAL SCHOLARSHIPS

The New York Post-Graduate Medical School and Hospital announces that there will be available this year six scholarships under the terms of the Oliver-Rea Endowment. The purpose of the Endowment is to award scholarships to practicing physicians of the United States to defray in full the expenses of tuition at the New York Post-Graduate Medical School. According to the wishes of the donor, physicians in the State of Pennsylvania will receive preference in the award of these scholarships.

Applications may be sent to the President of the New York Post-Graduate Medical School and Hospital, 20th Street and Second Avenue, New York.

In all examinations of children, and in the examination of adults for suspected fractures, leave the painful manipulations for the last.

FRACTURES OF THE HEAD AND THE NECK OF THE RADIUS.

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Fractures of the head of the radius are much more frequent than our present statistics would indicate.

Plageman, from the Rostock Clinic, found 23 cases in 3,664 fractures—1.65%. Thomas quotes it as occurring ten times in one thousand cases and considers fracture of the head and neck of the radius as more frequent than fractures of the patella.

The frequency of its occurrence is, however, not of as great importance as the failure to recognize the lesion once it has occurred.

One hundred and sixty-one cases have come under my observation. Of these ten occurred in children and the remainder were in adults. Twenty-six cases occurred in conjunction with dislocations at the elbow joint all in adults.

Previous classifications have divided the fractures of the upper end of the radius into those of the head and those of the neck. It would seem necessary, from the peculiarity of the region involved, to divide the fractures somewhat differently based more upon the relationship of the fracture line to the orbicular ligament and to the superior radio-ulnar joint.

In this paper I purpose to divide the fractures of the upper end of the radius into those which involve the radius within the joint capsule, and those which involve the bone between the capsule and the attachment of the biceps tendon. Many of the first group involve portions of the shaft and all produce disturbances of greater or less moment in the joint. The latter group are entirely extra-articular and are much less frequent in their occurrence. There are also marked differences in the symptoms produced, the treatment to be used, and in the result obtained.

The terms used in this paper will then be:

1. Fractures of the head of the radius. These include all those which occur in the region of the upper radio-ulnar joint capsule and include the epiphyseal separations.

2. Fractures of the neck of the radius. These include only those fractures that involve the bone below the region of the joint capsule and above the attachment of the biceps tendon. Tanton (in Nouveau Traitè de Chirurgie par Le Dentu et Delbet, Vol. IV, Paris, 1918, Vol. 1; p. 542 et seq.) evidently makes the same division.

FRACTURES OF THE HEAD OF THE RADIUS. (GROUP I.) occurred 150 times in this series, divided as follows:

10 cases in children (epiphyseal separations).
26 cases in adults in conjunction with dislocation of the elbow.
114 cases in adults without other lesions.
150.

FRACTURES OF THE NECK OF THE RADIUS. (GROUP II.) occurred eleven times in this series. All the cases were adults.

Mechanism: (Fractures of the head of the radius).

Thomas (*University of Pennsylvania Medical Bulletin*, Vol XVIII, 1905) concludes that the most frequent cause of this injury is a fall upon the hand with the elbow extended. In his experiments he followed Bruns' experiments by disarticulating the humerus and with the palm of the hand on the ground and the arm in extension struck blows upon

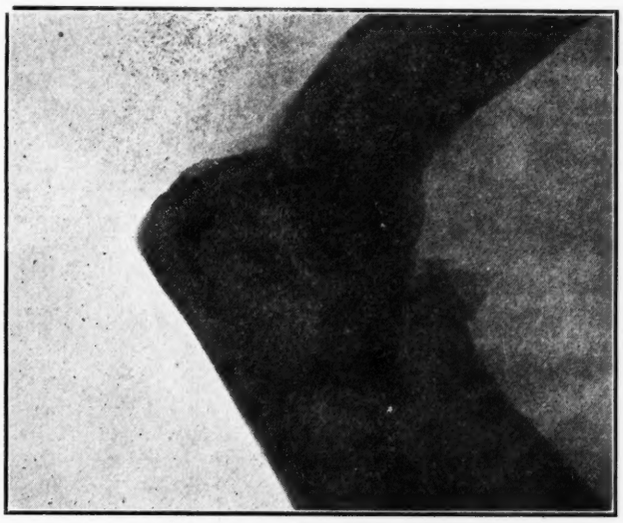

Plate I. Marginal fracture of the head of the radius in a woman aged twenty-five.

the head of the humerus. Thomas placed the forearm in nearly full pronation. He makes the point that the fragment which is anterior in pronation will be posterior in supination. The force applied to the head of the humerus in this way, by Thomas, smashed the humeral head without producing a fracture of the radial head. It was necessary to saw off the humeral head and apply the force (a blow with a mallet) to the sawed end of the humerus to produce the desired result. He succeeded in all except one of his ten attempts to produce a fracture of the head.

Von Lesser believed that forced flexion of the elbow, by drawing the radial head against the capitellum, produced the fracture.

Von Bergmann believed that the arm is in abduction when the fracture is produced by a fall upon the hand.

Stimson, Cheyne, Delorme report cases produced by direct violence over the head of the bone, and Stimson believed that the fracture might be produced by forced abduction of the forearm.

The history of the method of reception is clear and sufficient to determine the method of production in only 70 of the above 150 cases.

In two cases the children were leaning over to pick up something and the arm was jerked forcibly upward (radial abduction plus forced extension) producing a fracture along the epiphyseal line.

In one case the patient was struck by a falling timber on the semi-flexed arm raised to protect his head and there was an abrasion of the skin with a

Plate II. Same type of fracture as in Plate I, except that there is a large gap between the fragments on the articular surface. This does not show in the lateral view. Function was more interfered with than in the above variety. Man aged twenty-eight.

contusion over the head of the bone. In the remaining sixty-seven the injury resulted from falls upon the hand with the arm extended and in various degrees of pronation.

Pathological Anatomy:

Tanton (*vide supra*) gives a classification headed as *incomplete fractures* or fissures which run longitudinally through the head and usually involve the neck. A lesion of this type does not appear in my series. Two cases considered incomplete fractures by me which were subsequently submitted to operation because of the functional disturbance, showed radiating fissures of the head which however completely separated some of the fragments and were types classified as B (*vide infra*).

It is not possible from the *x*-ray plate alone to

state that the fragments are not completely detached by the line of fracture, and, as this variety is not as a rule submitted to operation because of the mildness of the injury and its subsequent recovery without the necessity for operation, it would seem wiser to include this group with the following group.

COMPLETE FRACTURES OF THE HEAD:

This type includes a large number of lesions of a very different type. In general they may be divided into:

1. *Those in which the displacement is very slight* and in which the injury to the surrounding orbicular ligament is practically nil. The lesion in the bone can best be shown by the following *x*-ray plates.

Type A. (Plates I, II).

In this type a small fragment is broken from the periphery with some slight separation of the fragment from the bone and depression of the fragment downward. In the mid-position between pronation and supination this fragment is on the antero-lateral aspect of the head and involves only a small portion of the cup of the articular surface. (This type corresponds to Tanton's "Fractures Marginales").

Plate III. (Type B) Note the same marginal fracture as is shown in Plate I, but with a second line of fracture through the neck with some displacement of the internal fragment.

Type B. (Plate III).

In this type the fracture line splits the head into a number of smaller or larger fragments which are but slightly displaced and there is a fissure which traverses the neck close to the attachment of the synovial membrane to the bone. This is a more severe injury than the previous one and there is apt to be some tearing of the orbicular ligament or the synovial membrane or both.

In one case (Jennie D., House of Relief, New York Hospital, *x*-ray plate 1588) there was a fracture of a portion of the articular cartilage of the capitellum and this fragment lay on its edge between the fragments of the head of the radius with one edge resting against the fracture of the humerus. There was considerable tearing of the orbicular ligament (Plate IV).

In another case (Caesario, House of Relief, New York Hospital, *x*-ray plate 227, Plate V) submitted to operation, there was a coincident fracture of the tip of the coronoid process of the ulna, the fracture line involving the lesser sigmoid cavity of the ulna. The patient was an Italian aged forty-four, who came to the Hudson Street Hospital with a history of having fallen down some steps, eighteen weeks before I saw him. He thinks his hands were in front of him. His arm was practically stiff, with no supination or pronation and about five degrees of movement in flexion and extension. At operation there was calcification of the anterior capsular ligament of the elbow and partial calcification of the orbicular and external lateral ligaments. There was also a healed fracture of the coronoid process of the ulna which was not visible in the *x*-ray plate. The head of the bone was broken into four or five fragments with very little separation of the fragments and with osteoid tissue springing from between the fragments which blended with the calcified ligamentous structure. The head of the radius, with the orbicular

Plate IV. Fracture similar in type to that in Plate III, but with a shadow between the head of the radius and the humerus which proved to be a fracture of the articular surface of the humerus displaced between the fracture fragments of the radius (see text).

ligament, and the calcified capsular and lateral ligaments, were excised. The resulting function six months after the operation was flexion, a loss of ten degrees, extension a loss of fifteen degrees with supination one-half normal, and pronation three-quarters normal, when the patient disappeared.

2. *Those with marked displacement of the fractured fragments.* (Plates VIII to XIV).

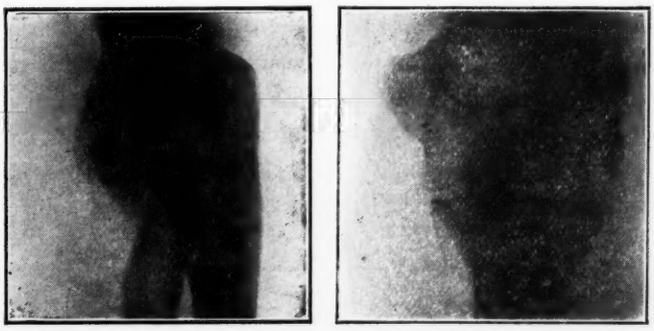

Plate V. Fracture of the characteristic type, but with ossification of the orbicular ligament, the anterior capsular ligament, and a portion of the external lateral ligament of the elbow joint (see text).

Plate VI. Epiphyseal separation in a girl of six, with the classical symptoms of injury to the head of the radius. The displacement is slightly outward and was not corrected. Function was practically perfect.

The fragments of the head may be one or many. Usually the line of fracture extends into the neck of the bone. The displacement of the fragments varies within wide limits also. It may be only a slight downward and forward displacement with rotation of one or more small fragments or a complete wide displacement of the head forward and laterally, sometimes as far as the internal condyle. In this variety the orbicular ligament is extensively torn and the bone fragments preserve little or no contact with each other. There is also some laceration of the external lateral ligament of the elbow joint.

In this group also are found the fractures of the head of the radius which occur with the elbow dislocations, and in these (dislocations) one also finds the torn capsule and ligaments of the elbow joint common to those dislocations, in addition to the injury to the orbicular ligament.

The essential difference in the two main groups, I and II, described above, is not so much the extent of the bone injury as it is the amount and degree of injury to the orbicular and associated ligaments and to the superior radio-ulnar joint.

Plate VII. Complete displacement of the epiphysis treated by open replacement (see text).

Epiphyseal Separations (Plates VI and VII).

The epiphyseal line in children lies within or very close to the attachment of the synovial membrane of the superior radio-ulnar joint to the radius, so that these injuries are, in part at least, intra-articular.

Broca considers the lesion as a fracture of the neck but the symptoms (q. v.) are so similar to those of the fractures of the head, and the joint symptoms are so common that I believe they should be classified in this group.

The youngest child was three years of age and the *x*-ray plate showed a roughening about the epiphyseal line with but little displacement. In the other cases

the displacement was forward and outward, and in one case the head of the bone was displaced out and

Plate VIII. Note the wide displacement of the fragments. One fragment lies in front of the ulna below the inner edge of the trochlea.

down so that the cup of the articular surface pointed directly outward.

Plate IX. The same patient as Plate VIII five years after the operation. This plate shows very beautifully the amount of ossification which occurs when the torn orbicular is left untouched, and also shows the irregular growth of the cut surface of the radius when it has been covered by muscle. The function in this case was extremely good and the newly formed bone apparently interfered very little with the movements in any direction (see text).

It seems possible from the youngest case in this series that the "subluxation of the head of the radius" described as a lesion in children under three years of age (Stimson, Fractures and Dislocations, Lea & Febiger, 1917, page 746 et seq.) may in certain cases be a separation of the epiphysis not readily detected even by the *x*-ray.

Symptoms.

The symptoms are fairly characteristic. Following the injury there is disability, more or less complete, at the elbow joint with inability to supinate the forearm. The arm is usually held in semiflexion and a little beyond the midpoint in pronation. Flexion and extension are possible but limited and somewhat painful, while pronation and, especially, supination are impossible without severe pain. Curiously enough, when the fragments are widely displaced

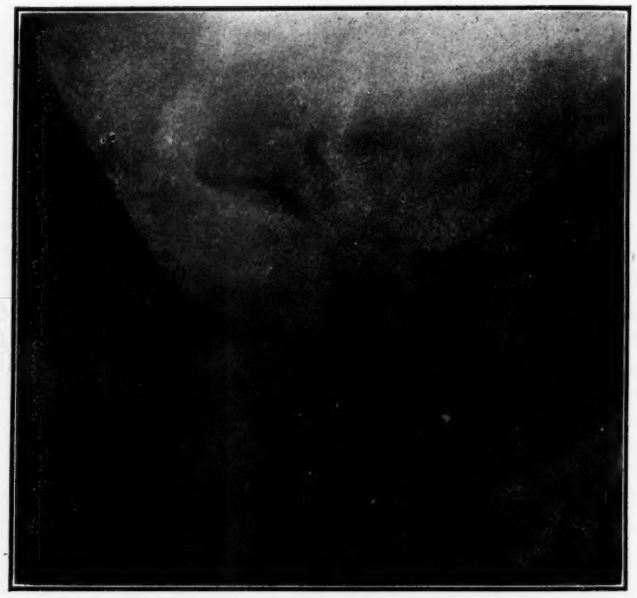

Plate X. Wide displacement of a large fragment.

the active movements in pronation and supination are relatively less painful than in the less severe injuries.

There is swelling in the cubital fossa and sometimes ecchymosis over this region, which later also appears over the external condylar region.

There is exquisite tenderness over the head of the radius increased by attempts at supination and made unbearable by abducting the forearm during this supination. That is, if digital pressure is made over the head of the radius and the forearm supinated and abducted there will be severe pain at the point of pressure, which may also radiate down the forearm. When such is the case a fractrue of the head of the radius is always present, and no other lesion at the elbow joint will give the same symptoms.

I have never felt crepitus, perhaps because I have never looked for it. When the large fragments are widely displaced they may occasionally be felt, es-

pecially as hard movable bodies just on the outer side of the biceps tendon.

In children, especially young children, the disability is complete but the arm is usually carried by the side in extension in the pronated position, and movements from this position cause pain.

The actual diagnosis must of course rest upon an *x*-ray examination, although the above symptom-complex is sufficient for a diagnosis.

An *x*-ray plate, especially stereoscopic plates, will show the location of the fracture and the amount and degree of the displacement, and is essential for the proper treatment.

Plate XI. Note the similarity in the displacement of this fragment to that of the epiphyseal displacement (Plate VII).

Treatment.

The treatment of fractures of the head falls into three groups and, as stated above, depends upon the factors outlined in the classification above given.

Group 1, Type A.—the marginal fractures. The arm should be splinted with the elbow flexed to a right angle with the forearm in the middle position between full pronation and supination and kept at rest during the stage of acute exudation and reaction in the superior radio-ulnar joint. Arbitrarily I have kept the arm at rest for five days. Daily massage, with baking by dry heat, is then begun and the patient is urged to use the arm, that is to make active movements in flexion and extension within the limits of pain. As soon as the patient finds that these movements can be executed without pain, usually in from five to seven days (the tenth to twelfth day after injury) movements in pronation and supination are encouraged and the splint is removed. The treatment is continued from four to six weeks, after which time more active movements on the part of the patient, with use of the arm, may be encouraged.

Plate XII. Note the rotation and upward displacement of a large fragment. The line of fracture was similar in character to that in Plate III, but with greater displacement of the fragments.

The average time consumed in the restoration of function to its final degree is eight weeks.

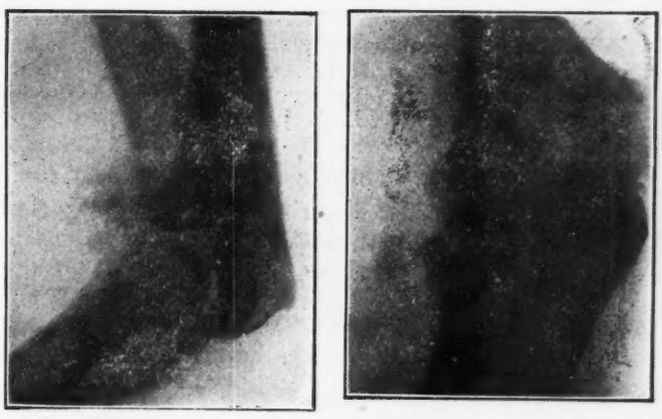

Plate XIII. An old case which shows displacement that was untreated. Also shows the proliferation of new bone with calcification of the ligaments. Greater disturbance of function after the operation than occurred in the cases illustrated by Plates VIII to XII inclusive, submitted to early operation.

The resulting loss of function for this group is relatively slight, about five degrees of extension and from five to ten degrees of supination. In women and children the loss in extension is less noticeable

than in the male adults due to the almost universal hyper-extension at the elbow in the former.

The splint used by me is a moulded plaster splint from the middle of the posterior aspect of the upper arm down the ulnar aspect of the forearm to the dorsum of the hand at the heads of the metacarpal bones. A well-fitting triangular sling is equally satisfactory, although the average patient feels more secure and better satisfied with the splint.

Operation is not indicated in this variety and any attempt at correction of the slight displacement which may be present is unnecessary.

In rare instances the small fragment may fail to unite and become a loose body in the superior radio-ulnar joint and cause disturbance in that joint. Such a case came under my observation in the Out-Patient Department of the New York Hospital. The injury was an old one and probably belonged to this type. Following a fall, six months before I saw him, the man, about twenty-five years old, was treated for a sprain of the elbow. After about a month he began to use the arm with pain, especially on supination. This has persisted and is especially bad after his day's work. Examination showed little except slight limitation of extension and limitation of supination to about half normal. Forced beyond this point there was crepitation in the joint and some pain. The *x*-ray plate showed a small fragment evidently detached from the head in the joint. Operation was advised for the removal of this fragment and refused. The removal of such a fragment would be the treatment for this rare complication.

Plate XIV. Shows an old untreated fracture of the head of the radius as the cause for the stiff elbow. The patient had a fresh fracture of the humerus for which I saw him in consultation with Dr. L. A. Wing.

Group I. Type B.—The early treatment is essentially the same as that described for the type A fractures, except that the hand should be carried into as much supination as the patient will permit. The recovery is apt to be less rapid and the function obtained is not so satisfactory as in the former lesion. The treatment usually requires from twelve to sixteen weeks before the restoration of function to its final stage.

Operation may be required for loss of function, especially supination, and for various complications, such as coincident fracture of the articular surface of the humerus, subsequent ossification of the joint capsule, etc. This is usually done late when it has been established that the above treatment will not suffice; and the method to be pursued will be described later.

Plate XV. Shows the result of the ideal type of operation (aperiosteal division of the radius with excision of that portion of the orbicular ligament which was badly torn) (See text).

There were 41 cases in this series that have been considered as Type B, with 7 operations. One was done on the seventh day after the injury (the case Jennie De C. with a coincident fracture of the articular surface of the humerus, Plate IV). The other six were for limitation of function, especially in supination and flexion, and all were markedly improved.

My experience leads me to believe that the time of election for the operation for the complicated cases in this series should not be later than the tenth week

after the injury, and should be done earlier if there is a coincident injury to the humerus (Plate IV). The result obtained, in my experience, is better in the cases operated upon at the end of eight weeks than those done later.

The criterion for operation is the failure to obtain a gradually increasing range of flexion, extension and supination. When this occurs, it is a nice point to decide whether to wait or to operate. If the individual is an artisan to whom the greatest obtainable function is a requisite, I believe operation is the method of election inasmuch as function is then more rapidly and more fully restored.

The resulting function for this variety (Group B) was a loss of extension of from five to ten degrees for the unoperated cases, and from ten to fifteen degrees of supination with a slight loss of pronation in one case. One case had only five degrees loss of supination and one case a twenty degree loss.

In the cases submitted to operation the best result was obtained in the case of Jennie de C. (Plate IV) submitted to operation on the seventh day. In this the loss of extension was five degrees, of supination between five and ten degrees.

Three cases operated upon before the tenth week had a loss of extension slightly less than ten degrees and about twenty degrees loss of supination.

Three cases operated upon later, eighteen, twenty, and twenty-four weeks after injury had between ten and fifteen degrees loss of extension, and about forty degrees of supination.

That is, the prognosis for function is relatively better for those cases submitted to the earlier operation.

There were 10 cases of epiphyseal separation in this series in children aged 3, 4, 5, 5, 6, 7, 8, 9, 9½ and 16. All were similar in type to that of the six-year-old child illustrated (Plate VI), except the youngest case in which only the epiphyseal line was hazy and the shifting of the epiphysis was comparatively slight, and that of the sixteen-year-old boy (Plate VII) in which the head of the radius was completely shifted so that it lay on the external aspect of the shaft of the radius with the cup of the head pointing outward. The symptoms in all were identical to those given above.

The treatment in all was similar to that outlined for the cases in Group I except that the arm was splinted at right angles in supination for a week, and then carried in a sling and the child encouraged to use the arm. Massage and baking were not needed and active movements were performed readily by the children when the pain had disappeared. In the sixteen-year-old boy an open reduction of the displaced head was performed on the fifth day after the injury. The orbicular ligament was torn from the anterior edge of the ulna at the superior radio-ulnar joint and the capsule stripped from the neck of the radius. The external lateral ligament was also torn. The head was replaced and the torn ligaments imperfectly sutured with some difficulty.

The resulting function was practically complete for all of the children except the last-named case (the complete displacement). In this case extension and flexion were limited about ten degrees, pronation twenty degrees, supination twenty-five degrees.

Plate XVI. Shows a myositis ossificans following a posterior dislocation of the elbow, mistaken for a fracture of the head of the radius. The case is unique in my experience.

Bolton, cited by Stimson, reported a similar replacement of the epiphysis but did not describe the resulting function.

In the fractures of the head with wide displacement of the fragments, there were 59 cases in this series with 58 operations. Twenty-six cases occurred in conjunction with dislocations of the elbow and 33 not associated with that lesion.

Because of the complicated tearing of the other ligaments of the elbow joint and the greater disability which results for that reason, the result of the treatment of the fractures associated with dislocation should be considered separately.

The lines of fracture in the head are numerous and are best described by the illustrations (Plates VIII to XIV inclusive).

The essential features of the treatment are removal of the head and neck as far down as the bicipital tubercle, and the operation should be done early—five to seven days after the injury.

The treatment of the torn orbicular ligament is a debatable question. If left as it is found at the operation or if closed by suture it becomes more or less completely ossified (Plate IX). This, however, has not interfered with the function in any of my cases.

The complete removal of the ligament is a rather formidable undertaking and in the one attempt I made I could not see any increased efficiency obtained by so doing. In general, I believe the best result can be obtained by simply excising the torn and shredded portions of the ligament and by leaving the remainder untouched and unsutured. I have also covered the end of the radius by fat, by muscle and by fascia,

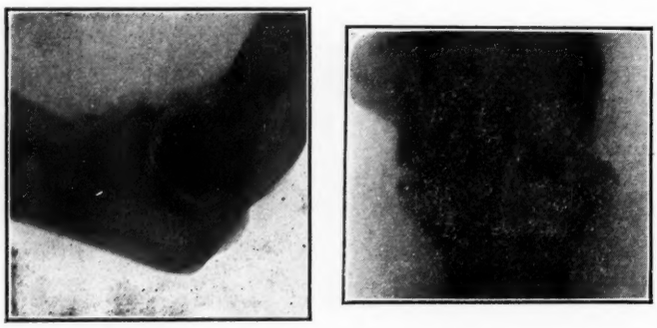

Plate XVII Fracture of the neck of the radius of the classical type.

but I believe that if it is treated by the aperiosteal method with removal of the marrow for a suitable distance (as in the aperiosteal amputations) the result is equally satisfactory (Plate XV).

Removal of the displaced fragment alone was done twice and the function was not nearly so satisfactory in these cases as in the complete removals (see Hitzrot, *Annals of Surgery,* Vol. XXXVII, page 354, for earlier report of 29 cases).

Forced movements at the elbow joint under an anesthetic are to be condemned. In one case in my series (Mrs. F., New York Hospital, 1920) the result of repeated efforts of this kind were an ankylosed elbow at the time the patient came under my care. Removal of the head and neck of the radius resulted in the return of all except ten degrees of supination, but flexion and extension were limited to about five degrees each way from a right angle by new bone deposited in the capsule of the elbow joint and were not improved by any treatment. This necessitated an arthroplasty with removal of the new bone and a portion of the articular surface of the humerus and the resulting motion of twenty degrees in flexion beyond a right angle and twenty-five degrees of extension beyond a right angle, i.e., a range of forty-five degrees of flexion and extension is extremely unsatisfactory.

Fracture of the neck of the radius (Group II, Plate XVII) occurred 11 times in this series and is a relatively less frequent injury. In an earlier report by the author (*loc. cit.*) only 4 cases reported in that series of 10 cases really belong in this group. The cases all occurred in vigorous young adults and were produced by severe traumas. Seven of the patients fell from various heights and think they landed upon the outstretched arm. One patient fell and wrenched his arm between the rungs of a ladder, and in three cases there was a definite injury by a direct blow over the radial side of the injured arm in addition to an indirect twisting of the arm proper.

The symptoms are also different from the injuries of the head. There is disability with pain on pronation and supination, but flexion and extension are relatively painless.

There is no tenderness over the head of the radius in the cubital fossa but the tenderness seemingly lies beneath the long supinator muscle. The head does not rotate with the shaft and crowding the arm upward while supinating the hand produces pain below the elbow joint deep in the arm at the location of the deep tenderness and *not* over the head of the radius.

As a rule, *x*-ray examination shows a fracture about midway between the cup of the head and the bicipital tubercle in the narrowest part of the neck of the radius. The line of fracture is irregularly transverse and there is but little displacement.

In my earlier cases I put the arm up in a sugar-tong moulded plaster splint in the mid-position, but this I believe is not the correct method as there is always a loss of supination when the fracture is treated this way. My later cases were treated by supinating the forearm fully and by the use of anterior and posterior moulded splints from the middle of the upper arm to the middle of the palm. The splints should be worn for four weeks; massage and gentle movements of the elbow in flexion and extension should be started on the tenth day; and pronation should be begun after the third week. The splints may be removed at the end of six weeks but function is not fully restored before the tenth to the twelfth week. Attempts to correct the slight displacement are futile.

The resulting function is very satisfactory. Flex-

ion and extension are practically normal. One patient had a slight limitation of flexion. Pronation and supination are limited by less than five degrees. (In the 4 earlier cases supination was limited from twenty-five to thirty-five degrees).

Two patients had pain upon movements in supination. In one of these there was a definite arthritis in the inferior radio-ulnar joint, possibly the result of an old injury the nature of which the patient described as a sprain some ten years before.

The *x*-ray plates in this paper are from the Hudson Street Hospital and the New York Hospital and in large part were taken for me by Doctor Busby.

FRACTURES OF THE FINGERS AND TOES.

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The surgeon practicing reconstructive surgery is occasionally confronted with deformities of the fingers and toes due to old undiagnosed or maltreated fractures of these members. Fortunately, the more universal early use of the *x*-ray and a better understanding of the principles of treatment of these conditions are reducing the time loss and deformities to a great extent. I have a number of these cases referred to me because of deformities following these fractures or because of prolonged disabilities. Numerous text-books on treatment of fractures are on our shelves and these deal with average cases. It is my intention, therefore, in this paper, to emphasize certain principles in the care of fractures of fingers and toes rather than to deal at length with the treatment of the various types of fractures.

The most important considerations in these cases are (1) diagnosis; (2) proper reduction and splinting with a view to obtaining perfect functional restoration; (3) treatment of the injuries to the soft parts which so frequently accompany fractures of fingers and toes, with the view of first saving as much function as possible in the tendons, nerves and muscles; the proper alignment and union of the fractures being of secondary consideration; (4) methods best adapted to overcome deformities and to restore function in the hand or foot.

DIAGNOSIS

The classical symptoms of fracture of the metacarpals or metatarsals, as well as of the phalanges, are swelling, a point of tenderness over the seat of fracture, ecchymosis occasionally, and pain on manipulation of the corresponding finger or toe. Crepitus, in my experience, is not as frequently elicited as some authorities state. Injury to the soft parts may cause swelling, tenderness, and pain on motion and may therefore conceal an underlying fracture.

All cases presenting the above classical symptoms, and all cases of injury to the soft parts, where the history indicates even moderate violence, should be at once submitted to an *x*-ray examination, although the roentgenogram will not always reveal the fracture unless taken in two directions—antero-posterior and lateral. This procedure will give the true diagnosis and will often show more than one bone fractured when only one bone was suspected. A routine *x*-ray examination of all hands in which one suspects fractures will fail to show a fracture in about 10% of cases, while all cases with swelling and tenderness in the foot following injury and subjected to *x*-ray examination will fail to show fracture in about 12% of the cases. The surgeon is scientifically and economically justified in subjecting his patient, an industry or the insurance company to the extra expense of an *x*-ray examination in those cases which fail to show fracture.

I have known insurance companies to complain of this apparently needless expense; but I have known the same companies to criticize severely a doctor who failed to take an *x*-ray picture at the time of injury because he didn't think there was a fracture, and yet 2 or 4 weeks later, because of continued tenderness and prolonged disability, an *x*-ray examination revealed the true condition.

I wish to emphasize, therefore, that in all cases of injury to the hands and feet, followed by swelling and points of tenderness, an *x*-ray examination should be made. In a small percentage of the cases a fracture will not be found but only in this way can the surgeon be sure of diagnosing all fractures that occur in these bones. Even when adhering painstakingly to this rule, a few of these fractures will be overlooked. But it is only after two or three experiences of being fooled by apparently trivial injuries to these parts that every physician becomes sufficiently wary to resort early to his roentgenograms.

After having completed my interneship in the Cook County Hospital and feeling quite cocky on my ability to diagnose fractures, I fell down miserably in two cases during my first year of private practice.

Mr. P., a close friend, called at my office two days after a slight injury to his hand. While boxing he felt a severe pain in his hand. It had swollen slightly and was still a little painful, especially when tying his shoe laces or writing. The examination revealed very few signs and I diagnosed a sprain of the hand and bandaged it in order to keep it at rest. It still continued to pain him at times but he was satisfied

with my reassurances that it would get better. Two weeks later he called because of considerable swelling over the back of the hand and exacerbation of the pain. I then suggested an *x*-ray examination and this showed a transverse fracture of the third metacarpal just above the head of this bone.

Mr. F., another friend, called at my office one morning. He stated that in jumping out of bed he had sprained his foot. He was able to walk on it but this caused some pain. Examination showed no swelling but some tenderness over the fifth metatarsal. The trivial nature of the injury, the fact that he could walk, and the absence of definite findings caused me to concur in his diagnosis of a sprain. A few days later he came in my office with his foot in a cast and walking on crutches. Another and wiser surgeon had resorted to the *x*-rays and had diagnosed the transverse fracture just below the tuberosity of the fifth metatarsal.

Since then I have seen many cases of fractures of the fingers, the result of injuries received in boxing, ball playing or falling on the hands. These do not always give immediate symptoms and undoubtedly many such fractures go undiagnosed, gradually healing without treatment. But careful examination will reveal immediately the point of tenderness, a slight crepitation, and limited function—sufficient signs to warrant an *x*-ray examination. (Fig. 1).

Mr. C's case illustrates another type of injury in which the fracture might easily be overlooked. He had struck another man in the face, cutting the proximal knuckle of his index finger on the man's tooth. Three days later he reported to me with a badly infected hand which required opening and treatment for several days. There was no sign of fracture but because of the nature of the injury and because the swollen, infected soft parts precluded a careful digital examination, a roentgenogram was made which showed a fracture of the second metacarpal with decided angulation.

The fracture of the fifth metatarsal described above is not an uncommon result of some apparently trivial injury. Sir Robert Jones is said to have fractured his fifth metatarsal while dancing. Jumpers have been reported to sustain this fracture. One employee stepped on a crow bar and twisted his foot. It was days before he reported to the plant surgeon because of swelling and pain. Considerable ecchymosis was present and the *x*-rays revealed a transverse fracture through the tuberosity of the bone. The mechanism of this fracture is said to be pressure downward through the cuboid while the foot is supinated or a pulling motion on the attachment of the peronei brevis muscle.

The following cases illustrate various types of overlooked fractures of these parts that have come under my care.

A man whose thumb was struck by a falling box forcibly abducting the member. It was treated for several weeks as a sprain and referred to me because of stiffness and continued pain. *X*-ray examination showed a fracture through the outer half of the base of the first metacarpal, extending into the joint, with only slight displacement.

This is a frequent type of fracture of the first metacarpal known as Bennett's "stave" fracture. Speed* described it as an "oblique fracture of the proximal end, the palmar fragment opening into the joint, and the distal portion being separated and dislocated backward to a varying degree." It often simulates a dislocation and differs from the separation of the epiphysis which has been described by Coues', Poland,† Sturrock and Speed.

"Stave" fracture of the thumb occurs from blows on the end of the thumb, or falls causing forcible abduction, or from direct violence over the joint. It

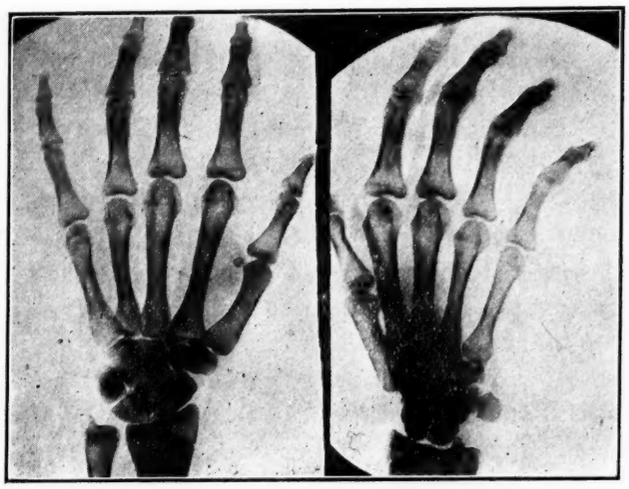

Fig. 1. Fracture of head of fifth metacarpal. At the time of injury a typical backward displacement of distal fragment simulated dislocation. The child's teacher reduced the apparent dislocation. Fracture not discovered until two weeks later when physician was consulted.

is comparable to fractures in the bases of the phalanges which are usually small cracks, accompanied by some dislocation, and which are spoken of as "base-ball fingers", due to the typical deformities which usually follow a strike on the end of the finger by a base ball. All of these are not fractures but many cases of fractures occur in the phalanges of ball players which are never diagnosed.

In industrial work it is very important to *x*-ray every case of injury to the joints that cause the pain and slight swelling so characteristic of a "base-ball finger". If you do not, some other doctor is likely to and you will be chagrined by having the employee report to his employer some morning that his family

*Fractures and Dislocations, (Lea & Febiger, 1916), p. 530.
†Annals of Surgery, LVI, 450.

doctor found a fracture when you were treating him for only a sprain.

A child developed a spindle-shaped swelling about the middle joint of her index finger. There was no history of injury, no pain, no ecchymosis and no tenderness on pressure. She was treated for one week by her family physician for rheumatism. Then her parents consulted a pediatrician who thought that it was a case of spina ventosa and referred her to me. The swelling prevented the typical appearance of a spina ventosa, and when I referred her to the *x*-ray laboratory, I felt that this was probably the condition present. The roentgenogram showed a fracture of the proximal end of the middle phalanx of the index finger. This child was accustomed to turning hand springs and it is probable that the injury occurred in this way. There was some angulation and the correction of this, with immobilization for two weeks, gave a perfect result. Without proper diagnosis, the deformity in this little girl's finger would have been permanent.

I have seen some workers who have sustained apparently trivial injuries develop swellings about the fingers or the back of the hand, without any pain or tenderness, and who have shown a transverse fracture of one of the metacarpals or of a phalanx on *x*-ray examination.

This case brings out the importance of the *x*-rays in the differential diagnosis of these cases of swelling about the hands or feet due to some obscure cause. For example:

Mr. S., 50 years of age, a tailor, struck the back of his hand against a gas jet pipe when reaching for his pressing iron. The blow was not severe but two days later there was some swelling. I diagnosed a slight contusion and advised resting the hand. The next day the swelling had increased and an *x*-ray picture showed a needle buried deep in the soft tissues of the back of the hand near the wrist joint. The swelling soon showed signs of infection. It was opened and the needle removed. This was followed for several days by a severe infection of the hand. This man could not recall ever having run a needle into his hand and neither could his mother recall such an injury when he was a child. When the *x*-ray was resorted to my diagnosis was a possible fracture of the base of the 3rd metacarpal bone because of the swelling and tenderness over this area.

Mr. R., 18 years of age, fell on his extended hand while at work. The next day there was considerable swelling and he was sent to the hospital for *x*-ray examination. The laboratory reported a small crack in one of the carpal bones. The wrist and hand were immobilized but the swelling increased in size, fever developed and the appearance was that of an infection. Another *x*-ray examination was made with both hands and wrist joints on the same plate for comparison. This revealed a slight change in all the carpal bones of the injured member as compared with the other wrist. The bone which had been diagnosed as fractured was now seen to be infected. Instead of a fracture we were dealing with a case of tuberculosis of the carpal bones, diagnosed within a week following a fall on his extended wrist. The process must have been present before this fall. This case illustrates the importance of reading and interpreting the *x*-ray plates yourself and also of taking a picture of the well member for comparison in case of doubt.

Mr. A., 47 years old, a butcher, twisted his foot while at work and it became badly swollen. He remained at home soaking it in hot water and rubbing it with liniment, under the care of his family physician, for five weeks. His employer grew tired of paying compensation for a simple sprain of the foot and so called to see me about it. I expressed the opinion that possibly his employee's foot was fractured and advised that an *x*-ray examination be made. A week later the case was referred to my service at Washington Boulevard Hospital. The *x*-ray examination showed a tuberculosis of all the metatarsal bones instead of a sprain or a fracture. The condition had undoubtedly been present prior to the slight injury complained of. Disability was greatly prolonged by lack of early proper diagnosis.

I have seen one case of swelling of the fifth finger, proximal joint, that developed after the girl employee had struck her extended finger against the typewriter. Pain and tenderness were absent. An *x*-ray examination was made at once and revealed a large bone cyst involving the entire proximal phalanx. This immediate use of the *x*-ray prevented a claim against the concern, for it was inconceivable that this slight trauma could have made this marked change in the bone. At the time the picture was taken I suspected a fracture.

Fractures of the phalanges very frequently accompany smashed toes due to heavy objects falling on them. These are very often undiagnosed. The crushed soft parts are treated but the fracture, undiscovered, is left to heal without treatment. Usually good union takes place but occasionally marked deformity results because of mal-union, non-union, or necrosis of the bone.

The case of Mr. M., 45 years of age, a trucker, illustrates this type of fracture. While at work a heavy truck passed over the toes of his right foot in November, 1920, crushing the soft parts severely. He was taken at once to one of our best hospitals by the insurance company. The surgeon to whom the case was referred was away and the interne placed hot dressings on the foot. The next day was Sunday and the surgeon did not visit the hospital. On Monday when he saw the foot the swelling had gone down and the soft parts were improved. The patient was kept in bed two weeks and then discharged as almost cured. As soon as he began to walk about, with the aid of a cane, pain and swelling returned in the toes. A few days later a small discharging sinus appeared in the end of the great toe and a little later sinuses appeared in the 3rd and 4th

toes. The company doctor treated these as infected soft parts. Under rest they would improve but when the man began to walk about they would grow worse. There was very little pain. This condition continued for eleven weeks before the insurance company decided to refer the case for special care. He entered my service in St. Luke's Hospital and an *x*-ray examination showed only a portion of the distal phalanx of the great toe remained acting as a foreign body; a necrosis of the distal phalanx of the 4th toe, and a necrosis of the distal phalanx and a portion of the proximal phalanx of the 3rd toe distal to an old transverse fracture. The soft parts over these necrotic bones were infected. Removal of the dead bones, trimming of the soft tissue and leaving the wounds open to heal by granulations resulted in complete recovery in three weeks and the return of this employee to work. (Fig. 2)

Fig. 2. Crushing injury of the toes, eleven weeks after the injury. Possibly a fracture of the distal phalanx of great toe with absorption of the bone. Healed fracture of the proximal phalanx of the great toe. Ankylosis of the joints of the second toe. Fracture of the second and distal phalanx of third and fourth toes, with infected processes active in the ends of the bone. Ununited fracture of the second phalanx of the fifth toe. Discharging sinuses in first, third and fourth toes. Infected soft parts excised and necrotic bone removed. Left open and healed by granulation.

This is not an uncommon history except that it is unusual for these cases of phalangeal fracture of the toes to pass through a good hospital undiagnosed. This fact adds emphasis to the importance of *x*-raying all crushing injuries of the toes.

Fractures of these phalanges are usually transverse or oblique; occasionally a portion of the bone is fractured off and remains ununited. Longitudinal fracture through the phalanx of the great toe is not infrequent. Speed reports an interesting case of the distal phalanx of the great toe being split into 4 pieces by longitudinal fractures. The blood supply in the phalanges is not rich—the distal phalanx having no periosteum. Therefore, it is not uncommon for non-union and necrosis to follow in the distal fragment of these fractures. Early diagnosis, proper alignment and keeping the patient absolutely off the injured foot for three to four weeks will usually result in union; but when signs of necrosis or persistent non-healing of the soft parts occur, removal of the fractured fragment is indicated and will hasten recovery.

Undiagnosed fractures of the metatarsal and other bones of the foot result in a greater degree of permanent deformity and a longer period of disability than do the undiagnosed fractures of the hand. This is due to the trauma to the fractured parts from weight-bearing. I have seen disability prolonged for more than a year, the result of undiagnosed fractures in the feet, and permanent deformity was the final result.

Mr. B., 32 years old, had his right foot crushed by a large amount of crushed stone falling on it. It was badly swollen and contused, when he was admitted to the hospital, and ice-bags were applied. Four days later a cast was applied without an *x*-ray examination being made (according to patient's statement). The foot became badly swollen and turned black and the cast was removed at the end of 4 days. After 2 weeks he was allowed up on crutches. The swelling and dusky color in the foot persisted and at times caused great pain. Treatment consisted of alternating rest in bed with hot dressings or ice-packs and periods of being up and around on crutches. This man was referred to me exactly ten months after the injury. He then had a slightly swollen foot, cyanotic, with ischemic and trophic changes along the outer lateral surface and a small pressure ulcer just back of the little toe. The toes were stiff and there was practically no lateral mobility in the foot. Flexion and extension of the ankle were limited. *X*-ray examination showed a fusion of all the metatarsals with a chronic infective arthritis between the metatarsal and tarsal bones. Signs of transverse fractures through the tuberosities of the metatarsals and through the cuboid were found. All fractures had united but the bones were plastered together by this infective exudate. Lack of diagnosis and allowing the patient to bear weight on these fractured bones had resulted in an ostitis and arthritis which in healing had permanently deformed the foot.

Severe crushing wounds of the hands or feet are

practically always accompanied by one or more fractures. One metacarpal or metatarsal may be fractured in two or three places. The determination of whether or not effort to save a hand or foot should be attempted depends partly upon the condition of these bones. Therefore the *x*-ray should be resorted to as soon as feasible in all these severe crushing injuries.

Severe injuries to other parts of the body may be accompanied with injury to a toe or finger resulting in fracture which is overlooked because the surgeon's attention is focused chiefly on the major injury. During the last year I have seen a case of severe skull fracture with a fractured phalanx of the 3rd finger; a case of ruptured liver with a fracture of the 5th metacarpal; and a case of severe contusions of the chest and back with a fracture of the 2nd metacarpal. In all cases of severe injuries careful examination of all parts of the body should be made. The surgeon should develop a system whereby he routinely examines an injured person thoroughly and completely and not the least of his attention should be directed to the fingers and toes.

Fractures of the great toe sesamoid bones, a rudimentary 6th metatarsal, tearing off a chip of bone from the joint surface with a dislocation of a phalanx, and other atypical fractures must be definitely diagnosed by roentgenograms.

The chief points to be emphasized, therefore, in the diagnosis of fractures of fingers and toes are:

1—A majority of these fractures give the classical symptoms of swelling, point of tenderness, ecchymosis or crepitus, but in these the *x*-ray must be resorted to in order to determine the type, number and location of fractures.

2—A considerable number of these fractures occur in cases where the history of injury or the findings are slight and, because the case hardly justifies the expense of an *x*-ray examination, the surgeon diagnoses a "sprain" or a "contusion". Later, because of persistent symptoms the *x*-ray is used and the surgeon is chagrined to find that he has overlooked a fracture.

3—The early use of the *x*-ray is indicated in all cases of swellings and points of tenderness following an injury to the hands or feet; and in all cases of swellings and points of tenderness, without history of injury, that are not definitely inflammatory changes or ganglions or tumor formations in the soft parts. The *x*-ray is necessary for differential diagnosis in some of these. (Fig. 3).

4—Many cases of fractures of fingers or toes are overlooked because of the severe injury to the soft parts. In all such cases roentgenograms are indicated.

5—Failure to early diagnose and properly treat some of these fractures results in prolonged disability and occasionally in permanent deformities.

TREATMENT OF CLOSED FRACTURES.

The treatment of fractures of the fingers and toes is most important, especially in industrial surgery, where much of the worker's skill may be lost by poor results. The greatest care should be used in setting these fractures and after reduction the result should be checked up by *x*-ray examination.

These fractures have been considered as minor injuries and too little attention has been paid to their treatment. The fees allowed by insurance companies for such fractures has relegated their care to the hands of unskilled physicians. For the same reason

Fig. 3. Contused and lacerated wound of back of hand. The patient entered with hand badly infected and *x*-ray examination showed fractures of fifth metacarpal and distal phalanx.

the *x*-ray has not been used sufficiently often to check up the results. The expense column has controlled the treatment of these cases to a too great extent. Surgeons should be paid more for the care of these fractures. At the same time insurance companies and employees and also the patients must be educated to the importance of using the *x*-ray to diagnose and to later guide the treatment. It would help considerably if a reduced charge could be made for fractures of the fingers and toes by *x*-ray laboratories, thus allowing two or three small plates to be made in all of these cases. The reduction of these fractures

under the fluoroscope is the most ideal plan that can be adopted. The portable *x*-ray apparatus is especially well adapted for this work.

Light plaster of Paris splints that can be moulded to suit any desired position of flexion or extension of the hand or fingers make undoubtedly the best universal method of holding these fractures. Splints are far preferable to casts, especially for fractures in the hand, as they can be easily removed and daily or every other day massage and joint motion allowed. Every type of metal splint recommended for use on the hand can be patterned out of plaster—the wide wrist band, the palm support, the long narrow strip for the finger, the Goldthwaite thumb splint (fig. 4) or the Jones shoehorn splint. Steel bars, ⅛ to ¼ inch size, can be readily bent to fit any position and incorporated in the plaster splint and extended beyond it, thus forming excellent means for traction. Sir Robert Jones in his new work on Orthopedic Surgery of Injuries gives an excellent description of this method.

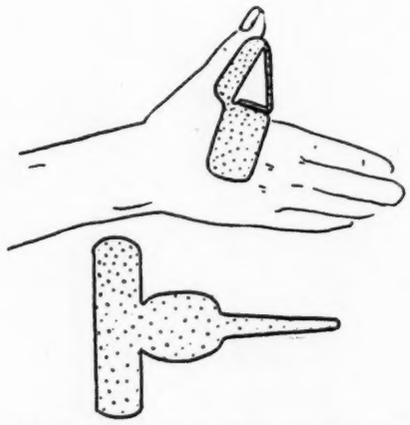

Fig. 4. Goldthwaite's thumb splint cut out of sheet metal and folded to fit thumb. (Speed)

The majority of the fractures of the fingers and toes are transverse or oblique, and because of the proximity of the other bones the displacement is usually not marked. In such cases the part is held by a splint, in as nearly normal position as possible, care being taken to prevent the bandages or the pull of the muscles or tendons from causing a displacement later.

In those fractures with displacement, careful traction and pressure and other manipulations must be used to reduce the fracture and gain proper alignment. In some cases this may require a gas anesthesia but as a rule pressure pads, continuous traction and splinting of the part in the best physiological position to give the desired end will suffice.

In the Bennett "stave" fracture of the thumb the best position is to splint the thumb in abduction and flexion. Jones says to have the thumb in the position assumed in grasping a tumbler. A plaster spica about the thumb may suffice. If there is much displacement of the fragment, traction should be used. Two adhesive strips wrapped spirally around the thumb and attached to a rubber band or tube and the latter attached to an extension on the splint will give excellent traction. This extension can best be made by using a U-shaped steel rod; apply a plaster splint to the back of the hand with a slide splint over the back of the thumb; incorporate one leg of the U in the palmar portion of the splint and one in the thumb portion. The Goldthwaite thumb splint (Fig. 4) or a pattern of this made of plaster, forms a good means of holding these fractures, as well as fractures in other portions of the phalanges of the thumb.

In fractures of one or more of the metacarpals

Fig. 5. Fracture of second phalanx of index finger after two weeks' treatment in complete extension. Note forward angulation which fixation in partial flexion would have overcome. Antero-posterior view appears normal.

there is a tendency for the distal portion to displace dorsalward and override the proximal fragment. A pad in the upper palm and a second pad over the lower back of the hand with a posterior plaster splint extending from three inches above the wrist down to the proximal phalanges of the fingers will usually suffice. If traction is necessary, use can be made of the spiral adhesive strips about the corresponding finger, attached by rubber bands to an extension similar to the steel rods described above, which are incorporated in the plaster splint. In case of traction the fingers should be somewhat flexed. Some authorities claim that traction on the fingers is not well tolerated but if released daily and massaged, trouble will be obviated.

The rule is for a fracture of a metacarpal just above its distal end to show marked dorsal displacement of the lower fragment thus simulating a dis-

location (Fig. 1). This is especially true of the fifth metacarpal and less often of the second. Pulling downward firmly the corresponding finger, and at the same time flexing it, will usually correct this deformity. Then the hand should be splinted with the fingers forcibly flexed about a roller bandage placed in the palm. This draws the extensor tendons taut over the fragment and usually gives perfect alignment. A plaster splint moulded over the back of the hand and around the flexed fingers or simply bandaging the hand in this position or the use of a strong adhesive plaster will hold the fracture. Care should be used in fractures of the second or fifth metacarpals that a tight bandage around the hand does not

Fig. 6. Marsee's tin finger splint.

cause lateral displacement of one of the fragments.

Fractures of the proximal phalanges of the fingers should always be splinted with the finger completely flexed in order to avoid the angularity which usually occurs when splinted in extension. This angularity is due to a forward pull of the interossei muscles on the proximal fragment when the fingers are extended.

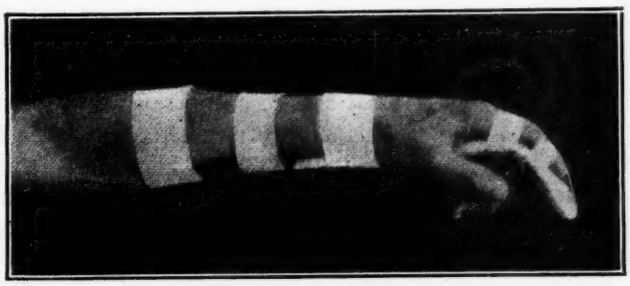

Fig. 7. Method of application of Marsee's finger splint before bandage is applied. Note natural curve of finger.

If healing is allowed in this position, this deformity occasionally prevents the complete flexion of the finger afterwards. Here again the roller bandage in the hand with the finger on either side of the injured one flexed with it may be best utilized.

In fractures of the two distal phalanges a natural flexion of the fingers is the best position for immobilization. I have seen in a few cases an angularity develop with the distal fragment forward at its upper end when the fingers were held in complete extension. (Fig. 5). This is an argument against the use of the tongue depressor as a splint unless it is so well padded as to give a double inclined plane effect. Marsee's tin finger splint, the long arm of which can be bent in the desired position of flexion, forms one of the best means of immobilizing fractures in the two distal phalanges. Here again I often use the moulded plaster splint. (Figs. 6 and 7).

In fractures of the metatarsals manual reduction is usually necessary if there is dorsal overriding. Traction is harder to obtain through the toes. For the first or fifth metatarsal a moulded lateral splint extending partly over the sole and partly over the dorsum furnishes excellent immobilization. If all the metatarsals are fractured, as often happens, careful reduction should be followed by holding the foot at right angles, padding the arch and encasing the foot and ankle in a plaster cast. (Fig. 8) This can be cut along its anterior aspect so as to be spread apart and removed like a shoe for massage after the fourth day. When replaced it can be held snugly by adhesive strips. I have already mentioned the importance

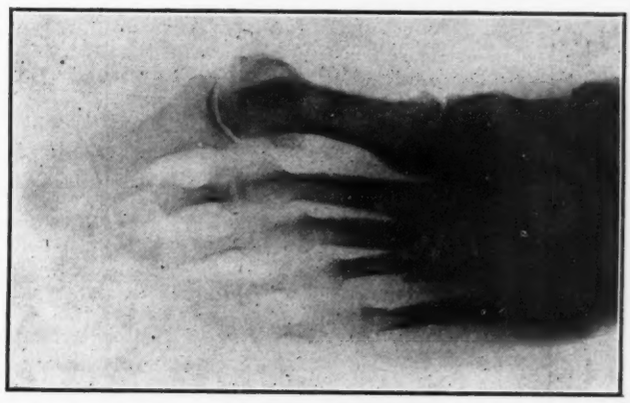

Fig. 8. Multiple fractures of foot treated by immobilization in a light cast.

of removing fragments or all of the distal phalanx in case of necrosis of the bone following fracture. This does not as a rule interfere in the function of the foot and will frequently save weeks and weeks of disability due to infection of the soft parts and persistent sinuses in the ends of the toes.

In fractures of the sesamoid bones efforts should be made to hold the fragments together with strong adhesive tape; keep the patient off the injured foot as in fractures of the other bones of the foot. The mistake is usually made in these cases of treating this injury as trivial and allowing the patient to use the foot too soon. In case of non-union and of persistent pain over the site of the sesamoid it should be removed. It is best to remove both of the sesamoids of the great toe if one must be removed as the other tends to drop down and cause trouble.

From two to three weeks must usually elapse before union is sufficiently strong in fractures of the fingers to permit discarding all splints. In the toes

three to four weeks is a safer period and certainly the patient should not be allowed to walk on the injured member earlier if such complications as painful, excessive calluses or infection of the bone are to be avoided in all cases.

INJURIES TO THE SOFT PARTS ACCOMPANYING FRACTURES.

Severe crushing injuries of the hand and foot with laceration and tearing of the muscles, tendons, nerves and bloodvessels as well as several fractures and displacement of the fragments of bone are of frequent occurrence. Many of these are so mutilated that amputation at once is necessary. But one is not justified in performing a classical amputation, cutting away sufficient injured tissue to enable making good skin flaps and a beautiful closure. In doing this

Fig. 9. Severe crushing injury of hand with multiple fractures. (Case of Dr. A. E. Halstead, St. Luke's Hospital.)

parts of the hand or foot are often removed which with care and patience could be saved and often would be of inestimable value to the patient later. A general rule should be adopted in these cases somewhat as follows: Cleanse the crushed member thoroughly with tincture of iodine, or with neutral soap followed by Dakin's solution as a wash; trim away as little of the mutilated tissue as possible; leave the wound wide open, introducing from one to eight Carrel-Dakin tubes into all the recesses and cavities of the wound; encase the hand in long sterile roller gauze dressings and about this place a large Carrel pad folded over the tubes and held in place with clothespins; place the injured member at rest somewhat elevated and preferably in a fracture box. Following this dressing, from 5 to 10 c.c. of Dakin's solution should be introduced into each tube every two hours. The dressings should be changed two or three times a day when saturated. Each day the mutilated member is carefully examined and when it is evident that a toe or a finger or a part of the hand or foot is completely dead, that portion may be trimmed away, usually without an anesthetic. Never attempt to make flaps but leave the wound wide open and continue Dakin's solution until healthy granulating tissue has appeared. If infection occurs, which is rare under this treatment, the wounds must be left open longer. Usually at the end of a week one has removed all tissue which could not live and he has to deal now with clean, although ragged, soft tissues. Plastic surgery can now begin, and it is surprising how much of a badly mutilated hand or foot can be saved and can be remodeled so as to give good function in the remaining portion. Fig. 9 illustrates a case of this type.

Mr. G. was recently admitted to St. Luke's Hospital on the surgical service of Dr. A. E. Halstead. (Fig. 9). Although the hand was so badly lacerated that immediate amputation through the base of the palm seemed indicated, yet no tissue was removed at the first dressing. The crushed hand was thoroughly cleansed with neutral soap and Dakin's solution, and three Carrel tubes inserted from the wrist down to the finger tips through and under the lacerated tissue. The next day it was evident that the tips of the third and fourth fingers were not viable and these were removed. On the third day the hand was badly swollen, and for one week a severe infection was present. The Carrel-Dakin treatment was persisted in, however, and gradually the infection was overcome. Most of the soft tissues had been torn away from the fifth finger. This finally had to be sacrificed. Gradually better alignment was obtained in the remaining three fractured fingers, the soft parts healed, and at the end of four weeks this man was undergoing massage and passive and active motion, and within a few weeks will, undoubtedly, have a remarkably good functional result, considering the seriousness of the injury.

I could give numerous examples illustrating the value of delaying amputation in these cases of severe crushing injuries of the hand or foot accompanied with fractures of the fingers or toes. In most of these crushing wounds, the following rules should be observed:

(a) Do not amputate and close the stump with nice skin flaps at once.

(b) Cleanse the wound thoroughly and apply that form of dressing which will prevent infection.

(c) Ligate bleeding arteries if necessary, but do not attempt immediate suture of torn tendons nor manipulation of the injured tissues, in order to reduce or secure alignment of the fractured bones.

(d) At each subsequent dressing, remove all tissue that is non-viable, but continue to leave the wounds wide open.

(e) When only healthy, non-infected tissues remain, plastic surgery on the soft parts and reduction of the fractures can be undertaken.

Compound fractures of the bones of the fingers or toes occasionally occur without serious injury to the soft parts, except the protrusion of the bone at the site of the fracture. Such fractures should be at once reduced and the wound to the soft parts cleansed thoroughly with iodine, or preferably with Dakin's solution. I am Dakinizing all such wounds for a period of three or four days before closing them; the fracture, however, is immediately reduced and immobilized by one of the methods described in the treatment of closed fractures.

RESTORATION OF FUNCTION

Surgeons have devoted almost their entire attention to standardized methods of reducing and splinting fractures and have neglected many of the therapeutic adjuncts of the greatest assistance in restoring function and securing rapid recoveries. Stimulated by the reconstruction work in the army, the profession today is paying great attention to the various types of physiotherapy. Massage, hydrotherapy, especially hand and foot whirlpool baths, and passive and active exercises, are the chief aids in restoring early function in fractured fingers and toes. Patients allowed to remain in splints or casts for three or four weeks without any massage or passive movement will often require three or four weeks more before they can flex and extend their fingers or before they can walk on their foot without pain and swelling. Massage and passive movements carried on simultaneously with the treatment of the fracture will, as a rule, restore function in the part within four weeks.

The commonest deformities following these fractures are ankylosis of a joint, due to a fracture in the joint and its involvement in the healing process; union between two of the metacarpals or metatarsals due to excessive callus; loss of extension of the fingers due to contraction of the muscles; adhesions of the tendons to the skin or bony structures; peri- or intra-articular adhesions; lesions of the ulnar or median nerve; loss or limitation of flexion due to adhesions of the tendons to the skin or their involvement in the callus, or due to peri- or intra-articular adhesions or to traumatic or postural contracture of the muscles; and deformities of the hand or foot, result of severe crushing injuries with fracture.

Persistent massage accompanied by hydrotherapy will overcome the majority of these deformities. Occupational therapy and mechanotherapy are of great value in these cases. Tate McKenzie, in his book on "Reclaiming the Maimed", describes many ingenious mechanical outfits that will assist in securing flexion and extension of the fingers and of the toes. Joseph M. Flint, in *Surgery, Gynecology and Obstetrics*, 1916, Vol. 23, p. 228, describes simple mechanotherapeutic apparatus for mobilization of fingers:—

"For flexion and extension of the fingers two types of apparatus were generally employed. One was copied from a machine which I used in the gymnasium as a boy. This consists of a series of wooden cylinders of gradually decreasing size arranged somewhat in the manner of a towel rack. The smaller cylinder is perforated and a cord passes through the hole and is tied. On the other end of the cord hangs a can of gravel which serves as a counter-weight. The action of this apparatus is obvious. The patients begin on the larger cylinders to wind up the counterweight which is in turn unwound by manual movements. After beginning with the larger cylinders, those of the smaller size are progressively used. This machine provides an excellent exercise for the wrist as well as the fingers.

"Another appliance for the fingers consists of a set of wooden cylinders each of which is covered by a cuff into which the fingers are inserted. By an angle of counter-weighted bands acting on these cuffs the fingers are held against the cylinders. This apparatus is then set in motion by a heavily weighted pendulum, which causes the cylinders to move back and forth through an arc of about 60°. As flexion of the fingers is gradually regained, smaller cylinders are successively used until both flexion and extension are complete."

In the United States Army, a heavy, well-fitting glove with leather straps attached to the end of the glove fingers and extending back through buckles at the wrist of the glove, was utilized for the gradual flexion or extension of stiff fingers. I have used this with great success in my private work since the war. The leather bands are fastened on the back of the glove when extension is desired, and on the palmar surface when flexion of the fingers is sought.

Forcible flexion or extension of stiff fingers under anesthesia is rarely indicated. As a rule, great swelling follows such procedure and the deformity is only intensified. Gradual methods of securing flexion or extension should be employed. The power that it is possible to exert without causing pain is very great and it can be graduated to a nicety. Whatever gradual method is adopted should be so arranged that the motion gained is never lost, and the traction on

the fingers is continuous. Daily massage and passive and active movement are absolutely essential parts of such treatment.

Operative procedures are occasionally indicated in order to overcome some of these deformities and restore function following fractures of fingers and toes. For example, tendons involved in the callus or adherent to the skin should be dissected free. Whenever possible, a pedicled flap of fat should be interposed to prevent re-adhesion of the tendon. Tendons that have been injured may require splicing or stretching. I have not found tendon grafts as successful in lengthening tendons as splicing.

Arthroplasty of the interphalangeal joints is indicated if deformity is due to a bony ankylosis. This operation can be performed under one-half per cent. novocain, a small fragment being removed from both bones or one-third of an inch can be removed from one of the bones only. A pedicled fat or fascia flap or free fat and fascia flap from fascia lata may be interposed. There has been considerable discussion as to the viability of these flaps. I have performed this operation several times, and believe in every case that the flap has become necrotic or absorbed. I have personally had no experience with heteroplastic substances, such as Cargile's membrane, pig bladder, boro-glyceride, etc. Results indicate that arthroplasty of these ankylosed finger joints is justified in efforts to restore function.

Occasionally ankylosis of the great toe joint following fracture of the first metatarsal will cause such pain and deformity that excision of the head of the metatarsal is indicated. I have removed the entire fifth metatarsal in a marked angular deformity of that bone with good result.

No treatment of fractures of the fingers or toes should be considered complete until every method has been exhausted for the best possible restoration of function in these members. Only in this way can the desired economic end-result be obtained.

122 SOUTH MICHIGAN AVE.

AMERICAN MEDICAL EDITORS' MEETING.

The 52nd annual meeting of the American Medical Editors Association will be held at the Hotel Lenox, Boston, Monday and Tuesday, June 6th and 7th, under the presidency of Dr. H. S. Baketel, editor of *The Medical Times*. At the sessions, which will be open to the profession, there will be symposia upon "Group Practice and the Diagnostic Clinic" and "The Attitude of the Profession towards Health Centers."

CENTRAL DISLOCATION OF THE HIP.

With Report of Three Cases.

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CINCINNATI.

Central dislocation of the hip is a descriptive title applied to those fractures of the acetabulum in which the force has been long enough continued or is sufficiently great to carry the head of the femur mesially, this is, through the acetabulum into the cavity of the pelvis. Fractures of the pelvic ring are relatively common and sufficiently characteristic to present few difficulties of diagnosis, but indiscriminate grouping of all fractures of the pelvis under the one classification of "pelvic fractures" will do little toward a development of a higher diagnostic art, and add little to the knowledge of acetabular fractures. So fractures of the acetabulum must be viewed as an entity having peculiar characteristics.

Specializing of our knowledge is again desirable because the satisfactory treatment of a fracture today presupposes a knowledge of: the force or violence producing that lesion; the location and type of the fracture; the pathway taken by the dislocated fragments; the anatomical obstructions to a replacement of those fragments; the forces tending to maintain the parts in mal-position; all the possible complications as well as the mechanical principals needed for a retention of the parts in a corrected position. Fortunately several of these requisites have been satisfied through the information given us by the modern roentgenologist; also he is rapidly changing rare clinical entities from curiosities to conditions of clinical and forensic importance.

In 1788, Callisen first described this condition and some thirty years later Sir Astley Cooper reported a case in detail. Occasional cases were reported from that time on to date and the most complete report with summary of the reported cases (53) appeared in the *Northwestern University Medical Bulletin*, June 1909, by Schroeder. However, all of these cases are not strictly speaking proven central dislocations of the femur. Since Schroeder's summary there are not sufficient reports to bring the total over 75 so that one is justified in considering this a rare condition. A number of text-books do not mention the condition at all as, for example, Scudder's "Treatment of Fractures" and the "Oxford Loose Leaf Surgery".

The acetabulum is a deep hemispherical cavity with a raised border; it is composed of parts of the ischium, ilium and pubes; the ischium contributing most and the pubes the least. The lines of union are

roughly Y-shaped and frequently in the younger subjects fracture follows these sutures. The floor of the acetabulum is very thin, even translucent, and the thinnest part is the lower portion, while the upper and posterior parts are the strongest. It will therefore be seen that the relation of the head and neck of the femur to the acetabulum is very important and only when the leg is in abduction is there the greatest pressure on the thinnest part of the acetabulum. Violence, to reach the acetabulum, must be directed through the femoral head; it is therefore indirect except in those almost theoretical cases of a possible missile injury direct to the acetabular wall. Investigation of the studied case histories shows that the violence has consisted of falls on one or both feet or knees and in most instances falls on the side of the hip, the force being applied through the trochanter. This injury has been compared to the driving on of a hammer or axe-head by striking on the end of the handle. After the injury has occurred and the femoral head lies within the pelvis all the muscle groups, flexors, extensors, abductors, adductors and rotators about the hip act to continue and increase the displacement, and this force must be overcome for satisfactory treatment. This muscle force is greater than that about any other fracture of the body.

Henschen gives a very satisfactory classification of these cases as follows:

(1) Central acetabulum fractures.
   (a) Simple radiating non-depression Y-fractures; linear or semicircular fractures.
   (b) Fragments displaced inward with subluxation of head.
   (c) Fragments completely displaced—dislocation of the head.
(2) Excentric fracture of rim.
(3) Ring-like separation of acetabulum with displacement inward of acetabulum and head. (Not a true central dislocation as acetabulum itself is not fractured).
(4) Combination of any of the above with fractures of the pelvic ring. Complicating injuries to soft parts and viscera.

I have tabulated some 56 cases from the literature, many of which are not proven true central dislocations of the femur. Of this number but seven were females; this however, means only that man's work produced situations of greater liability. Six of 45 cases, where the age is given, were under 20; 16 between 20 and 30; 9 between 30 and 40; 4 between 40 and 50; 6 between 50 and 60. In no instance was the injury classified as direct, and in but 8.1 per cent. was the force described as being applied through the feet or knees. In the remaining 90.9 per cent. the force was transmitted through the trochanter.

A great many of the earlier case histories omit the mention of many symptoms recorded in the more recent ones. Two inches is the maximum amount of shortening, though in a large majority the presence of at least some shortening is indicated. The "flattening" of the trochanter, or a "sunken" trochanter, is perhaps the most characteristic single symptom and a disturbance of the relation of the trochanter to Nelaton's line is constantly present, as is also Allis' sign.

Fig. 1. P. M. B. No. 3484—Acetabular fracture of first degree with simple radiating fracture of acetabulum. No luxation of head.

Inversion of the foot is reported but eversion is the more constant symptom. The absence of crepitus is frequently commented on with surprise. In practically all cases of more recent years the rectal and vaginal examinations have disclosed tenderness over the acetabulum or the buldging mass of the dislocated bone. All active motions are limited by the patient because of pain and reflex spasm, but when one picks up the leg he is surprised to find passive motion in all directions not limited but freely possible. Very considerable pain is complained of not only about the hip but also referred to the knee.

The brutal violence of the force that produces a central dislocation of the hip is so extreme that many times immediately fatal trauma is produced through

injury to the large bloodvessels or the hollow pelvic and abdominal viscera. Later fatal complications due to infections may cause death. Pelvic ring fractures may be multiple due to transmission and expenditure of the force along the various bony arches of the pelvis. One can thus see that in addition to the symptoms of the central dislocation *per se* there may be added all the variety of complicating symptoms associated with the great number of not infrequently coexistent injuries. It is safe to say that the prognosis as to life is good provided the associated injuries are of themselves not fatal. Prognosis as to the function depends, in the fully developed dislocation, upon an early recognition and correction of the deformity. Delay means the ankylosing of the femoral head in the faulty position with a ring of callus thrown out by the acetabular fragments. A few of the histories state that the individual is completely crippled and in one museum specimen the femoral head is embedded in a mass of new bone within the pelvis. In the uncomplicated case seen early and cared for promptly and efficiently the functional result is surprisingly good. Some pain is complained of and a slight limp may persist.

In making a differential diagnosis an impacted fracture of the femoral neck and the other forms of dislocation, particularly the "pubic" variety must be considered. Also multiple fractures of the pelvic ring are to be thought of and the possibility of a central displacement of a part of the pelvis due to multiple fractures or association of these with the true central dislocation must not be lost sight of.

The treatment of the simple case consists in lateral traction and longitudinal Buck's extension and counter-extension to overcome the muscular pull. A reduction of the bone through the hole in the acetabulum can best be accomplished with the leg flexed at right angles to the body and a pull up on the leg made together with the lateral pull and counter pull. At least three assistants are needed and the patient can best be handled upon the floor. Weights sufficient must be applied to accomplish the desired result. Proper lateral traction is hard to maintain because of pressure on the vessels and nerve trunks. In the second case here reported this was overcome by using a padded circular plaster cuff around the upper thigh. Passive motion should not be started until the acetabular callus is sufficiently strong to bear the pull of the muscles.

CASE I. (Reported by me in the *Lancet-Clinic*, 1915, Vol. CXIII, p. 392.)

On February 5, 1915 W. G., (Cincinnati General Hospital, No. 192141,) male, 49 years of age, while at work on a ladder fell 15 feet striking on the left hip, chest and elbow. Could not get up because of the pain in his hip. He was admitted to the East Surgical Service just before the moving to the New City Hospital Buildings. Examination of his left leg showed about three-eights of an inch shortening. The position of eversion was more comfortable though he could rotate the leg to the inverted position with pain. Pain about the hip produced fully 50% loss of function but passive motion could be made. No crepitus could be detected and there was no dislocation or swelling about the left hip. The trochanter was less prominent than that of the opposite side.

X-ray examination showed a fracture of the left acetabulum with a central dislocation of the head of the femur of about one-half inch. Rectal examination elicited marked tenderness in the neighborhood

Fig. 2. Case 3. H. C. No. 67556—Acetabular fracture of second degree with fragments displaced inward and sublaxation of the head of femur.

of the acetabulum. No extension was used. Sand bags were used about the leg. He was kept in bed eight weeks.

Under date of March 10, 1915 the history record states "Patient has almost full motion of left leg"; under date of April 6th "Full function with slight tenderness"; under date of April 26, 1915 "Patient discharged. Full function, though has pain up and down leg to knee". I regret these *x*-ray plates were lost in the confusion of the moving of the Hospital.

CASE II. On June 6, 1920, Mrs. E. N., (No. D3727) age 40, was admitted to the City Hospital on the Second Surgical Service with a history of having fallen two and one-half stories to the pavement while cleaning windows. We do not know where the greatest blow was given. She was unconscious for a short time. Temperature 95°, pulse 128, respirations irregular. Later she was delirious. Marked echymosis about and subconjunctival hemorrhage of left eye developed and she gave evidence to warrant a diagnosis of fracture of the base of the skull in the anterior fossa. This latter was later con-

firmed by the *x*-ray examination and during the next six weeks there developed a complete atrophy of the left optic nerve. She had no light perception and no pupillary reaction and today is totally blind in the left eye. The right eye remained about normal.

The shock was such that our first attention was directed to combating this and no extensive manipulation or examinations were made in the first few days. A rather extreme Colles' fracture of the left wrist was put up in a temporary splint, and sand bags were placed about the right leg and thigh. No swelling existed about the hip. The right leg was almost two inches shorter than the left. The foot was held in eversion though it could be passively rotated, but this caused great pain and muscle spasm about the hip. So, too, flexion, adduction and abduction of the thigh were possible. The fascia lata was relaxed and the first impression was that of a fracture

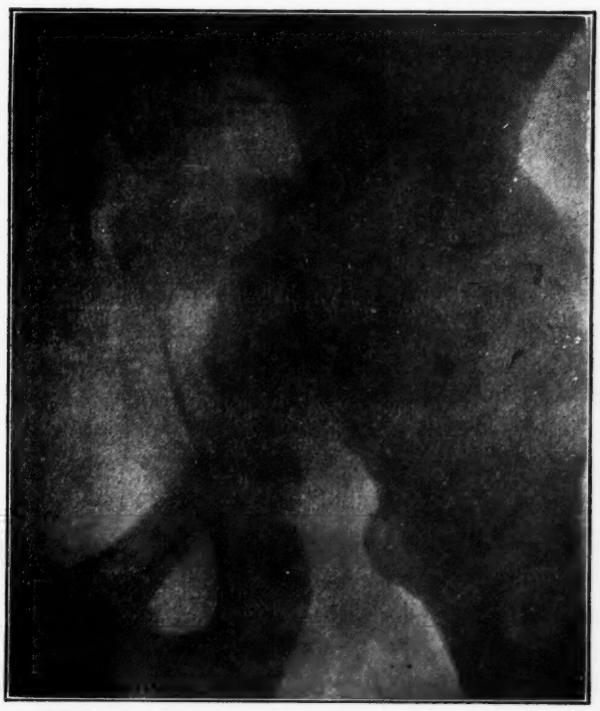

Fig. 3. Case 2. Mrs. E. N. No. D3727—Acetabular fracture with true central dislocation of the femoral head. Picture taken after first attempt at reduction.

of the femoral neck. After the primary shock was improved the "sunken" position of the trochanter was noted and led to the suspicion of a central dislocation; on vaginal examination the large rounded mass of the femoral head and acetabular fragments could be readily felt in the right side of the pelvis. This was tender and slight crepitation could be detected, but no crepitus was noted at any time from the manipulation of the thigh.

X-ray report, made June 7th: A fracture of the right acetabulum with the head of the femur forced through the acetabulum into the pelvic cavity. No evidence of injury to femur. There is also a fracture of the ischium". (fig. 3)

Four days after admission, under ether anesthesia, the effort was made to withdraw the femoral head from its pelvic position with partial success, as the *x*-ray plates show. Very considerable force was needed and used both laterally and in the long axis of the body; at the same time pressure was made from within the vagina but this was not great as we feared laceration of the soft parts by the bony fragments. Two weeks after admission a second anesthetic was given and the greatest improvement was accomplished with the thigh flexed at right angles to the body. (This fact is commented on in the case report of Dr. Wm. Fuller, *Journal of the A. M. A.* 1911, 141, p 390). The pelvic mass largely disappeared as well as the shortening. Buck's extension was applied, together with lateral extension outward of the injured thigh, with counter lateral weight extension applied to the pelvis just above the trochanter. We endeavored to keep these weights up to 20 pounds as she was a large well-muscled woman, but these were frequently reduced temporarily because of the bitter complaint of the patient.

Extension as above described was continued for about six weeks. Then passive motion was begun at the hip. She was allowed up after twelve weeks and discharged in four months. During the last month, gymnasium exercises greatly helped in a return of function in the hip. She was walking with crutches when she left the hospital. Last week, about 9 months after her injury, I saw her and with a three-eighth inch raised heel, she walked splendidly with but very little limp, and no pain except that in bad weather, or after unusual effort, the pain, referred to the knee, was quite severe. Measurements from the anterior superior spines to the internal malleolus was 94½ cm. on the left and 93 cm. on the right side.

CASE III. On October 25, 1918, H. C., No. 67556, male, age 48, was admitted to the First Surgical Service, Cincinnati General Hospital. I am not familiar with this man's history as I did not see him and the history on record is incomplete, so that I can give only a few of the details and show the *x*-ray picture (fig. 2) which is interesting and represents the second class of acetabular fractures. His injury was caused by a fall of 12 feet off of a trestle, alighting on the left hip. The tentative diagnosis was, as so often is the case, a fracture of the neck of the femur. He was in bed for some six weeks, was allowed up a couple of weeks before discharge and had only a rather marked limp at the time of discharge.

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THE WHITMAN ABDUCTION METHOD IN THE TREATMENT OF HIP FRACTURE.

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The Whitman method of abduction in the treatment of fractures of the neck of the femur represents nothing new, but the subject is so extensive that it can always be discussed with advantage. I have been familiar with this method of treating femoral fractures for eighteen years and have employed it with uniformly good results.

One of the primary objects in the treatment of fracture is the restoration of function. Whitman claims, however, that this purpose has never governed the treatment of fracture at the femoral neck, ostensibly because: (a) the mechanical conditions would make it impracticable, (b) it would endanger life, (c) the tissues would be incapable of undergoing the necessary reparative process. Moreover, any attempt to restore complete function would be futile, because the means at our command were inadequate in actual application.

The foregoing statements may be readily verified, since the basis of all treatment in common use is traction on the fractured limb. Traction properly applied and supervised may be efficient in the treatment of fractures of the shaft of the femur, the muscular tension thus produced materially aiding in the production of proper alignment, and security is assured by the formation of external callus. Traction is not efficient, however, in fracture of the projecting neck as it can at best only appose the fragments in a lateral and therefore insecure relation. Repair is not aided by external callus, but must proceed from within, and therefore a type of fixation is required that can be secured only by direct pressure.

To show how some of the earlier writers on the subject considered fractures of the hip, I quote a few:

(1) Restoration of form and function is rarely to be attempted or even sought.

(2) The first indication is to save life, the second to get union, the third to correct or diminish displacement.

(3) It is a crime to disturb an impaction in reasonably good position.

(4) Intracapsular fractures are practically never united by bone.

(5) Our prognosis must always be unfavorable. In many instances the injury proves fatal, and in all the function of the limb is forever impaired, no matter whether the fracture has occurred within or external to the capsule. Whether it has united by ligaments or bone, shortening of the limb and lameness are the inevitable results.

The universal outcome of the different methods of treatment may be appreciated when it is remembered that of one hundred and twenty ununited fractures of the hip observed at the Mayo Clinic not one had been treated by the Whitman method. Willis Campbell, of Memphis, reports one hundred and fourteen cases of fracture of the femoral neck. Of these twenty-nine were central or intra-capsular and were treated by the Whitman abduction method. Twenty-four gave good functional results, by which is meant that the patient walked without support, pain or discomfort and there was every evidence of bony union. The treatment resulted in failure in four cases, and the outcome was unknown in one. He also reports a series of forty-four cases of ununited fracture of the neck of the femur all of which were central, not one trochanteric or subtrochanteric being found. Of these sixteen were treated by Buck's extention, nine by the application of a plaster cast without regard to reduction or the position of abduction, four by Hodgens' splint, nine by sand bags, two by osteopathy, one ambulatory. In five the diagnosis was not made and consequently no treatment was applied.

Whitman claims that if the fragments are brought into correct anatomic apposition, there is no age limit to the possibility of union. On my service at the Louisville Public Hospital, early in 1920, I saw a woman aged one hundred and six years with hip fracture. Her youngest daughter was seventy-five years of age and so feeble that she was unable to visit her mother at the hospital. This patient was treated by the Whitman abduction method with the head of the bed elevated. At the end of six weeks when the plaster was removed firm union had occurred, but I regret to say she died within ten weeks from the date of fracture. Some one suggested that possibly she may have died from old age!

Non-union of hip fractures in children was one of the things which caused Whitman to seek some method of fixation so as to bring the fragments into correct anatomic apposition. That was about 1890, long before the surgeon considered it safe to open joints or even nail the fragments together. Twelve years afterward he first applied his abduction method, and it was a little later that I had the pleasure of working with him.

From my own experience and the observations of others, I believe the method of treatment that will relieve pain and shock, prevent bed-sores and at the same time promise the patient restoration of func-

tion, is much more conservative from a life-saving standpoint than neglect and its consequences represented by some of the plans now in vogue.

In the Whitman method the injured limb is covered with a stockinette or a flannel bandage which extends from the toes to the axilla; all bony prominences are well padded with cotton or silence cloth which is soft and does not become packed; the padding and bandages must be smoothly applied as every wrinkle will cause increased pain. This dressing should be worn for eight to twelve weeks. A general anesthetic is always administered while the dressing is being applied. Ether or nitrous oxide gas and oxygen may be satisfactorily used for this purpose. The patient is then placed on a Hawley table by preference if one is available. A pelvic support, or an ordinary flatiron with the handle padded, is placed under the buttocks to elevate the body slightly from the table, the shoulders resting on a hard pillow or box of the same height as the pelvic support. With two or more assistants the injured leg is abducted to the extreme limit, i. e., 45°; the sound limb is also abducted in like manner to fix the pelvis. Traction with internal rotation of the foot is then applied upon the injured side, and a plaster of Paris bandage adjusted extending from toes to axilla, great caution being exercised that the plaster is made thickest at the hip and knee joints which are always the two weakest points. Another feature which tends to make the dressing more comfortable is to cut the plaster around the thigh and pelvis. With this dressing properly applied the patient can be turned from side to side, or on his face, without the least discomfort; he can also be placed in a wheel chair with a board of suitable length to support the injured leg and taken out of doors when the weather permits. With ordinary care, which can be given by members of the family under direction of the surgeon, the patient can be kept comfortable. A bedpan can be placed under the body and removed without causing pain or inconvenience.

After the plaster is removed the patient remains in bed for several weeks. Each day the leg is abducted to the limit and massage practiced, the knee joint moved, etc. Weight-bearing is not permitted until there is free and painless motion and it seems certain firm bony union has occurred. Of course this is best determined by roentgen ray examination. If this method is not available then the surgeon must consider the ability of the patient to move the leg without pain, and the position of the foot on the injured side which should remain upright with little muscular effort, in estimating the amount of bony union. I do not consider one year any too long in which to secure a satisfactory result in fracture of the hip.

Some of the advantages of the abduction method are: (1) there is no shortening of any consequence, (2) the lessening of pain and ease of handling the patient, and (3) the high percentage of satisfactory function secured.

The surgeon need have no fear about applying this method of treatment regardless of the age of the patient. The administration of morphine will not be necessary, and if the patient is given proper care there will be no bed- or pressure-sores. In the aged I sometimes place the hip in slight flexion to insure greater comfort while the patient is "propped up" in bed; but, as already stated, the head of the bed can be elevated ten or twelve inches and the same result secured. Some of the instrument houses made a portable hip extension apparatus which is very strong and may be advantageously used if desired while the plaster dressing is being applied.

INTERTROCHANTERIC (PERTROCHANTERIC) FRACTURE OF THE FEMUR.

Based on a Study of 120 Cases.

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Apparently there has developed a misunderstanding of just what an intertrochanteric or pertrochanteric fracture of the femur is, and how often it occurs. The old distinction between intra- and extracapsular fracture of the neck of the femur has been dropped by men who know. We do hear of fractures through the narrow portion of the neck, near the head, and of those through the base of the neck. This study was therefore undertaken to attempt to demonstrate the relative frequency of intertrochanteric fractures and to give a general review of 120 cases. An investigation of that number was considered sufficient on which to base some general conclusions.

Sir Astley Cooper, in his "Fractures and Dislocations" (New Edition 1844, p. 152, Marvin, Boston, and on through into his Fifth Edition, 1851, p. 183) describes this type of fracture from a post-morten specimen. Smith ("Fractures in Vicinity of Joints," Dublin 1854, p. 95) also describes them and Hamilton in his "Fractures and Dislocations" (Sixth American Edition, Lea's Sons & Co., 1880) calls them fractures through the trochanter major and

base of the neck of the femur, mentioning but five known cases, none of them his own. In his description of fractures of the neck of the femur without the capsule (ibid, page 419) Hamilton says "These fractures may occur at any point external to the capsule, but generally the line of fracture is at the base, *corresponding very nearly with the anterior and posterior intertrochanteric crests.* Almost invariably the acetabular penetrates the trochanteric fragment in such a manner as to split the latter into two or more pieces. The direction of the lesions in the outer fragments preserves also a remarkable uniformity; the trochanter major being usually divided from near the center of its summit, obliquely downwards and forwards toward its base, and the line of fracture terminating a little short of the trochanter minor, or penetrating beneath its base; while one or two lines of fracture usually traverse the trochanter major horizontally." Hamilton's description, then, of fractures of the neck without the capsule about corresponds with our modern idea of intertrochanteric fracture. In 1895 three other authors mentioned this type of fracture: Bennett (*Brit. Med. Journ.,* 1895, II, 893); Stokes (ibid, page 881); and Kocher (*Ann. Suisses d. Sc. Med.,* 1895, III, No. 72). It has been named after one of them, Kocher. Other references: Cotton (*Boston Med. and Surg. Journ.,* 1916, CLXXV, 439); Gerster (*American Journ. Med. Sciences,* 1913, CXLVI, 172). In 1916 this fracture was described and illustrated thoroughly in my text-book on "Fractures and Dislocations" (Lea & Febiger, 1916). Again in 1920 I called attention to it in my report before the Fifth International Surgical Congress in Paris and also in an article this year (*Archives of Surgery,* II, 45). Solitary cases have been reported by Wilensky (*Surg. Gyn. and Obst.,* 1920, XXX, 244); Wassink (ibid XXXI, 636), and Skillern from Muller's service at the Polyclinic Hospital, Philadelphia (*Annals of Surgery,* LXXIII, No. 2, 227).

Definition: Intertrochanteric fracture of the femur is that fracture in which the main plane of bony separation passes from the tip of the greater trochanter obliquely downward and inward to or through the lesser trochanter. Depending on the degree of violence in the cause, there may be impaction of the acetabular fragment into the shaft fragment or a comminution into two or more distinct fragments.

Incidence: In a consecutive series of 501 fractures of the femur admitted to the Cook County Hospital, Chicago, intertrochanteric fracture occurred 120 times, or 24% of all fractures of the femur. In a slightly different series of 526 cases of fracture of the femur at this hospital collected by me, intertrochanteric fractures occurred in 118 instances or 22% (*Archives of Surery,* II, 45).

Age: The average age of these 120 patients was 62.1 years. Only one case occurred in the first decade of life, and only 3 in the second decade.

Sex: There were 71 males, 49 females in the series.

Mortality: Of the 120 patients, 20 died, a mortality of 16 2-3% . Of these, 9 were in females, 18.4 % of all females; 11 deaths were in males, 15.5% of the males. There were no deaths from fat embolism in the series.

Cause of Fracture: A large majority of the patients gave a fall onto the hip as the cause. They fell off steps, off street cars, downstairs, or off low elevations. All instances of intertrochanteric fracture arising in the younger patients (below 30 years of age) gave a very definite history of severe direct trauma. The only very young patient (a six-year-old boy) fell out of a swing from considerable height, landing on his hip. Amongst the 3 cases in the second decade of life, one fell 20 feet from a roof onto a cement sidewalk and the 2 others were struck in the hip region by automobiles.

Methods of Treatment: The treatment offered these 120 patients was:

Rest in bed	65
Buck's extension and bed	23
Plaster of Paris cast with legs in abduction	31
Open operation (screws and bone peg both inserted)	1

Results: All patients surviving (100), except one, obtained bony union. This one was recorded as having a fibrous union. However, as only 6 weeks had elapsed between the time of fracture and discharge in this particular case, judgment could not sensibly be passed on the type of union present. In all instances the bony union was checked by clinical examination and skiagram.

A small amount of actual shortening—¼ to ¾ inch—was the usual result. All patients surviving were able to leave the hospital walking on crutches or by aid of a cane after an average stay of 8½ weeks. The functional use of the hip joint was generally restricted, but promised to increase rapidly. Apparent shortening was very rare.

Mechanism: A glance at the neck and trochanteric region of the femur demonstrates at once the following points:

The head is rounded, covered by a thin shell of cortical bone, whereas its inner mass is composed of

closely meshed cancellous or spongy bone. Its function is to permit the ball and socket hip joint motions and to transmit force of weight bearing or trauma

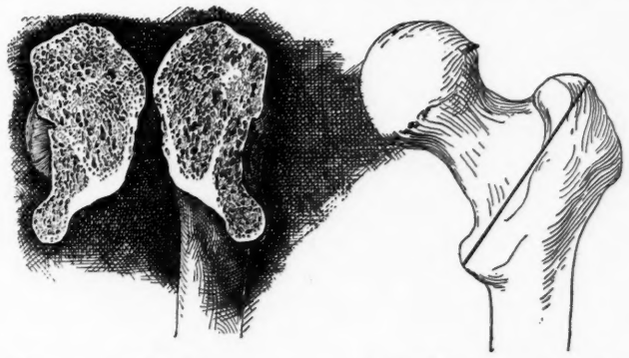

Fig. 1. A. Showing inter- or pertrochanteric area of a femur through which a saw was passed.

B. The sawn open intertrochanteric area. Note the large surface of cancellous bone exposed by a straight plane through this region. A bony union following fracture here would be expected regardless of treatment followed.

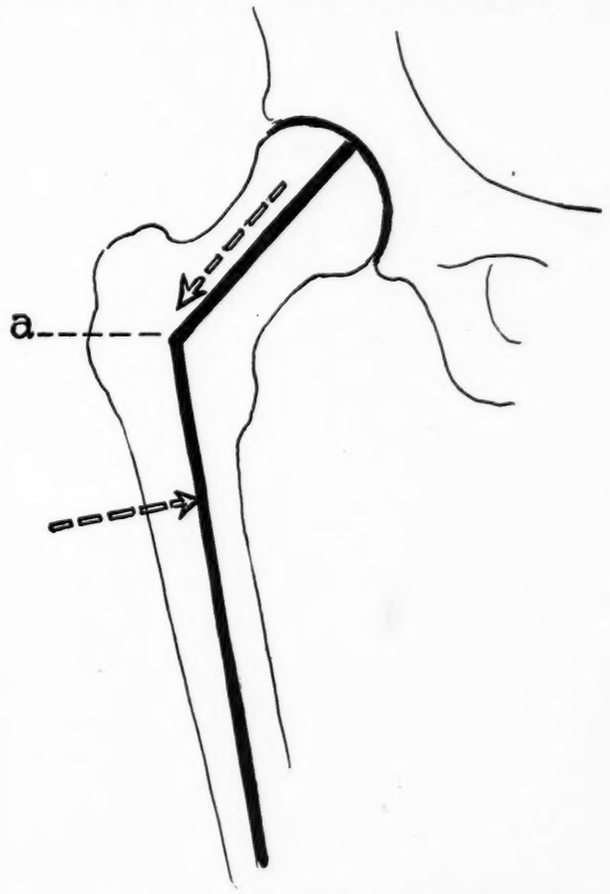

Fig. 2. Schematic representation of lines of force affecting femur in fall on the hip when the thigh is held tensely in slight abduction and external rotation by the muscles attached to the greater trochanter. The body weight passes down through the neck of the femur; the force liberated by striking the ground with the hip and thigh sharply adducts the thigh as indicated. The bone consequently bends and tends to give at "A", the apex of the convexity of the bone, and separation will start at or near the summit of the greater trochanter. Note the change in the long axis of the femur at "A".

coming from either below upward or passing from above downward through the leg. The neck is similarly constructed, strengthened by bone trabeculae laid down its longitudinal axis and by the calcar femorale. The trochanteric portion of the bone is broadened and roughened, affording knobs for muscular attachments to the flexors at the lesser trochanter and the strong abductors and external rotators of the thigh at the greater trochanter. In addition to muscular attachment we have the powerful Y ligament attached in this area in front. Bigelow (The Hip) states that this is the strongest ligament in the whole body and that its function is one of checking extreme motions of the hip, the inner band restricting the extension of the femur and the outer band, outward rotation. The trochanteric portion of the bone is also spongy, meant by nature to take up stresses and strains, and to pass on force without losing its continuity. This area then is an *extremely powerful portion of the bone,* built to resist shocks and pulls when they are applied in the normal and usual direction of weight bearing and muscle stress, a fact to which I have called attention in discussing the applied physics of human bone. (*Surgical Clinics of Chicago* 3, No. 4, August, 1919, p. 1007.) (See fig. 1). However this thick cancellous portion of the bone is also the part in which the direction of the longitudinal axis of the bone changes. That is, the direction of the long axis of the neck must turn through an arc of 50 degrees to pass on down in the direction of the longitudinal axis of the shaft of the femur. This is shown by the normal angle of the neck onto the shaft equalling 130 degrees. (See fig. 2). The intertrochanteric area consequently must also be extra strong to transmit forces either up or down the longitudinal axis of the femur through this portion which takes a small turn around the corner.

In discussion of the mechanism of intertrochanteric fracture, Wilensky says: "It seems most probable that the injury results from a play of force in which an extraordinary overextension of the trunk at the hip joint occurs in the dorsal direction with, and upon, the lower limb as a relatively fixed pivot; an enormous strain is transmitted through the unyielding Y ligament which, while incidentally aiding the muscles very powerfully in fixing the upper end of the bone, at the same time determines a line of greatest weakness and least resistance in the bone. In attempting to recover the balance, the long flexor muscles of the thigh are very strongly contracted and a powerful stress is exerted across the length of the femur which has the tendency to bow the femur in a forward direction. A sufficient continuation of the indicated stress and strain results in a solution

of continuity, and the latter must necessarily take place at the line of least resistance, later determined by the Y ligament, which corresponds with the lowermost line of attachment of its fibres a little below the junction of the neck and the shaft of the bone." Though this mechanism may account for isolated tearing off of the lesser trochanter which usually occurs in runners whose backward foot slips and permits forcible hyper-extension of the leg (or of the body if the leg were fixed), it cannot account for a solution of continuity diagonally through the trochanteric bone. It might be responsible for some sub-trochanteric fractures of the femur.

In mechanical analysis, intertrochanteric fracture is a compression fracture, caused by the direct trauma of a fall on the hip which sharply adducts the thigh. In compression fracture the plane of bone separation starts on the convex side of a bending compressed bone which may be compared to a beam supporting a force acting at right angles to its longitudinal axis. The individual who suffers this fracture falls off a height, a car, a ladder or even from a standing position as on an icy sidewalk. He must fall laterally or backward, generally the latter. If he fell forward he would sustain a Colles fracture, a dislocated elbow, a fractured humerus or clavicle. But he falls backward heavily. He has possibly tried to save himself by a powerful action of the external rotators or extensors of the thigh; they are in rigid contraction. Suddenly he strikes the ground. The force of his whole momentum is transmitted through the pelvis to the head of the femur and on downward to the ground as he strikes in the region of the upper thigh and trochanter. This supplies a powerful force acting in that direction. As he strikes the ground resistance the thigh held rigidly in some degree of abduction and external rotation by the contracted muscles attached to the greater trochanter is suddenly and most powerfully adducted. The two forces acting in these nearly opposite directions cause the bone to bend; it tends to bend at a point A (See fig. 2) where there is a normal angle in the longitudinal axis, and this point becomes the convex side of the bending beam or bone. Consequently if force sufficient to result in fracture is present, a plane of separation will start at the apex of this bend. That is, the plane of separation of the bone will start at or near the greater trochanter, and pass obliquely, as in most compression fractures, toward the opposite side of the bone, toward the lesser trochanter. This is exactly what is shown by skiagrams of incomplete fractures in this region. (See figs. 3 and 4). If the force is stronger and acts beyond a result that ends in incomplete fracture, we will find complete fracture with the thigh further adducted, the angle of the neck

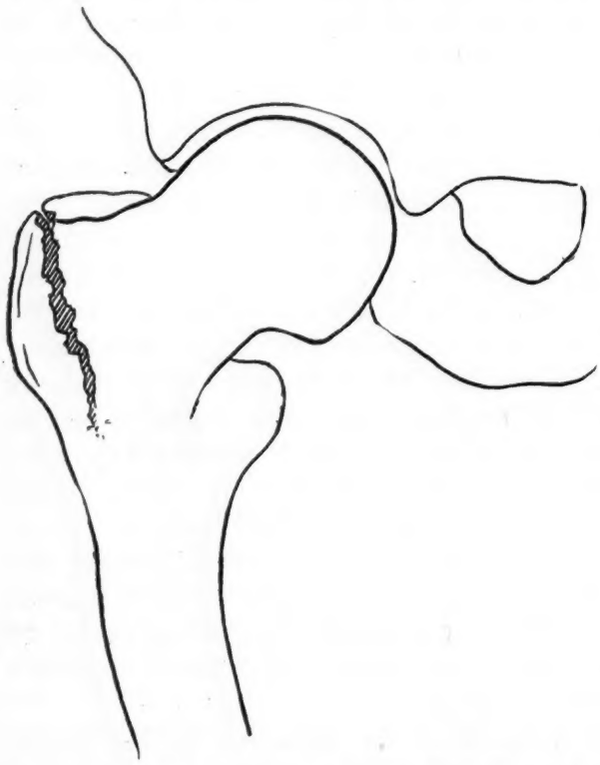

Fig. 3. Incomplete intertrochanteric fracture. The plane of bone separation starts at the summit of the greater trochanter and points down and inward. The angle of the head fragment to the shaft remains unchanged.

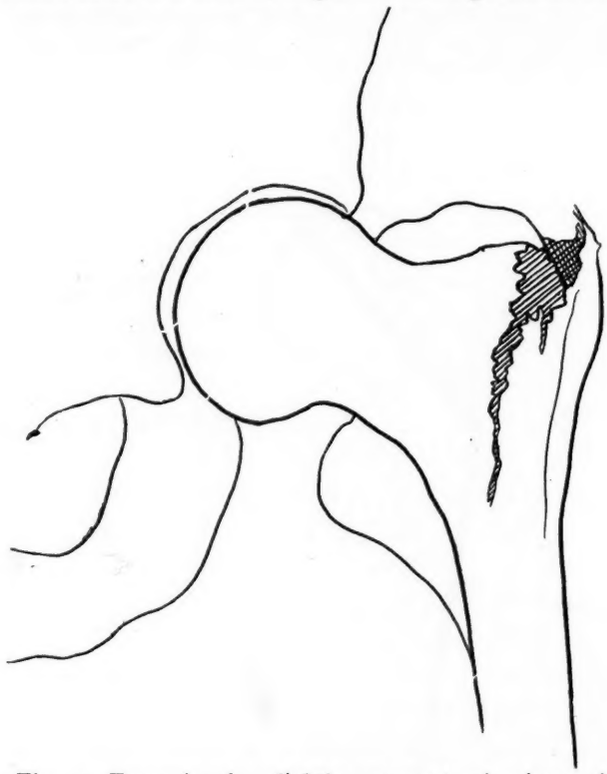

Fig. 4. Example of a slightly more extensive incomplete fracture,—the plane of separation not quite reaching the opposite side of the femur. The angle of the neck might be slightly reduced as it is in this case.

reduced to 90 degrees, or even less, the tip of the greater trochanteric portion shoved up toward the pelvis and the lesser trochanter squeezed off as a triangular fragment, as in ordinary compression fracture. (See figs. 5, 6, 7, and 8). The greater the vio-

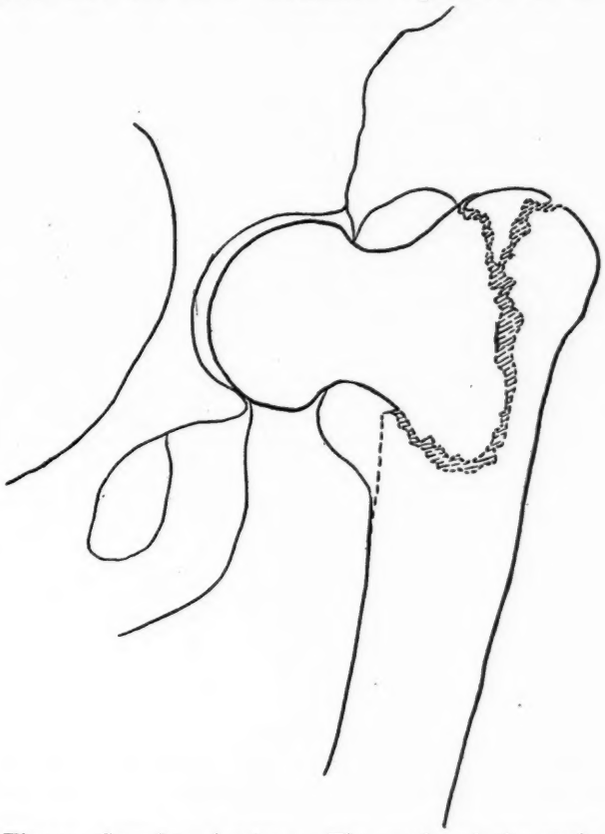

Fig. 5. Complete fracture. The angle of the neck is reduced to less than 90°. Impacted.

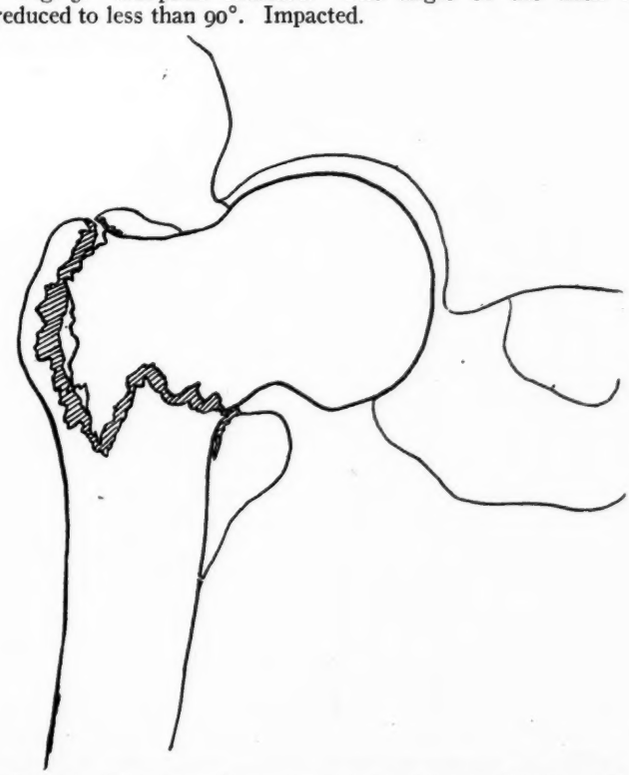

Fig. 6. Complete fracture with slightly different plane of separation assuming a right angle. The tip of the greater trochanter is separated and the neck angle is reduced.

Fig. 7. Complete fracture with 3 fragments and wide separation. Note the triangular lesser trochanteric fragment squeezed off. The neck angle is reduced and some shortening of the leg is present although the greater trochanteric summit does not seem much elevated. It is difficult in such a case to decide whether the trochanter rises above Nelaton's line or not.

Fig. 8. Complete fracture with 3 fragments, impaction of neck into shaft, and change of neck angle.

lence, that is, the greater the body weight, momentum, or height from which the fall occurs, the more complete the fracture and the greater the possibility of comminution into 3 to 5 fragments as different diverging planes of fracture manifest themselves. We would expect, if this mechanism is the real explanation of intertrochanteric fracture, to find that there is more or less impaction of the two fragments. This is almost always present in complete inter-

Fig. 9 Complete intertrochanteric fracture with no impaction and little disturbance of neck angle. This is the result of reduction on a fracture table.

Fig. 10. Complete fracture with changed neck angle. No impaction. An unusual finding.

Fig. 11. Complete fracture with slight impaction. Note the plane of separation starting down the shaft of the femur.

Fig. 12. Complete fracture with a transverse line through the greater trochanter. Note the impaction of the neck fragment into the shaft.

trochanteric fracture; the neck or acetabular fragment is driven into the cancellous tissue of the upper shaft. (See figs. 9-19, inclusive.)

When a patient falls on the greater trochanter with leg unabducted and external rotators not contracted, we would expect to find as a result fracture of the femoral head or neck or occasionally central dislocation of the head of the femur.

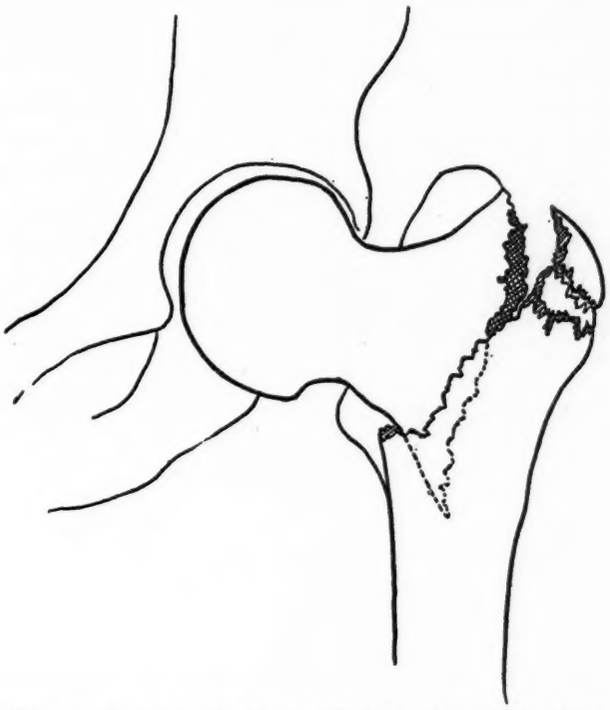

Fig. 13. Complete fracture with impaction. Note the reduced neck angle.

Fig. 14. Complete fracture with impaction below and separation above at the summit of the greater trochanter, furnishing a neck angle of 90°. This is the usual fracture.

Compression mechanism described thus explains the following points in intertrochanteric fracture:

Fig. 15. Complete fracture with impaction with the shaft fragment elevated to cause more than average shortening of the leg for this type of injury.

Fig. 16. An impacted fracture in an adult man.

(a) Impaction of the upper or neck fragment into the lower fragment which is shown quite constantly in this study of 120 cases.

(b) Reduction of the angle of the neck to 90 degrees, the usual finding.

(c) Planes of fracture *always* starting at the greater trochanter and passing obliquely down and inward.

Fig. 17. Complete fracture. The shaft rides upward.

Fig. 18. Complete fracture, impacted, with some separation of the lesser trochanter.

(d) Comminution into 4 or 5 fragments sometimes found.

(e) Additional planes of fracture sometimes found extending down into the shaft of the femur.

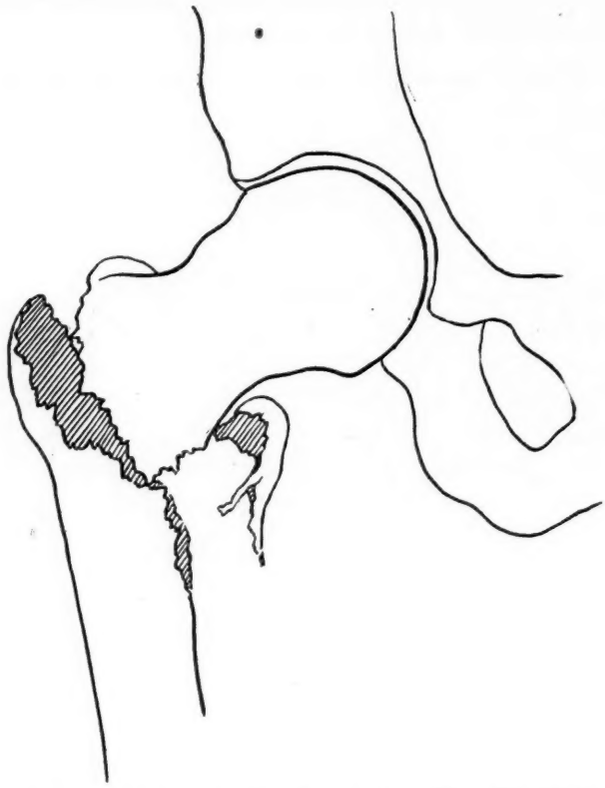

Fig 19. Complete impacted fracture with wider separation of the lesser trochanter.

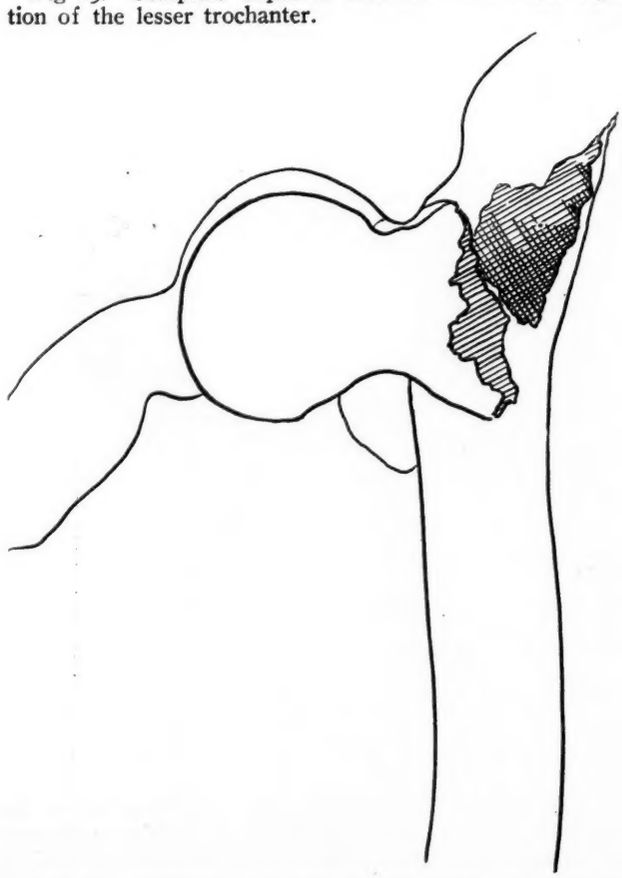

Fig. 20. Extreme elevation of the shaft fragment after intertrochanteric fracture. This would give a maximum shortening of the leg.

(f) Certain visceral symptoms showing injury of the bladder, kidney and intestine.

Because the average age of persons sustaining these fractures is over 62 years, we would expect some age and disuse atrophy of the cancellous bone in the intertrochanteric area which possibly would favor fracture. Those cases of intertrochanteric fracture arising in youth or young adult life are always accompanied by intense violence, because in the average young adult the extra strong bone of the intertrochanteric region is powerful enough to sustain average falls without suffering a solution of continuity.

Signs and Symptoms: The adult patient cannot usually walk after sustaining this fracture. He must be carried away from the scene of accident. Younger individuals suffering intertrochanteric fracture with or without impaction or with incomplete fracture frequently walk after a fracture of this type for several days before its true nature is recognized. This is in contradistinction to the average fracture of the neck of the femur. Therefore immediate loss of function is variable. Shortening may or may not be present—usually is very slight even to expert measurement. Swelling and fullness with late appearing ecchymoses about the hip region occur in the severe complete intertrochanteric fracture. The axis of the limb may be little changed. The foot does not tend as a rule to lie inert and helpless on its outer aspect. Crepitus may be easily perceived on slight motion of the hip when there is complete fracture with separation. Impacted fracture gives no crepitus and the trochanter may be felt to move in rotation with the shaft. This may be painful.

The relation of the upper border of the greater trochanter to the Roser-Nelaton line may be unchanged. It was slightly elevated in 40% of our cases. (Figs. 20 and 21).

Attempts to abduct or externally rotate the injured leg were particularly painful. This finding is almost always present. Visceral symptoms may be present. Two patients of this series presented hematuria, in one case lasting 30, in the other 24 hours. One patient had a large bloody stool twice following the accident. One had symptoms of intestinal obstruction. These symptoms add confirmation of the traumatic cause of the fracture. The bone pathology in every case in this series was confirmed by roentgenogram.

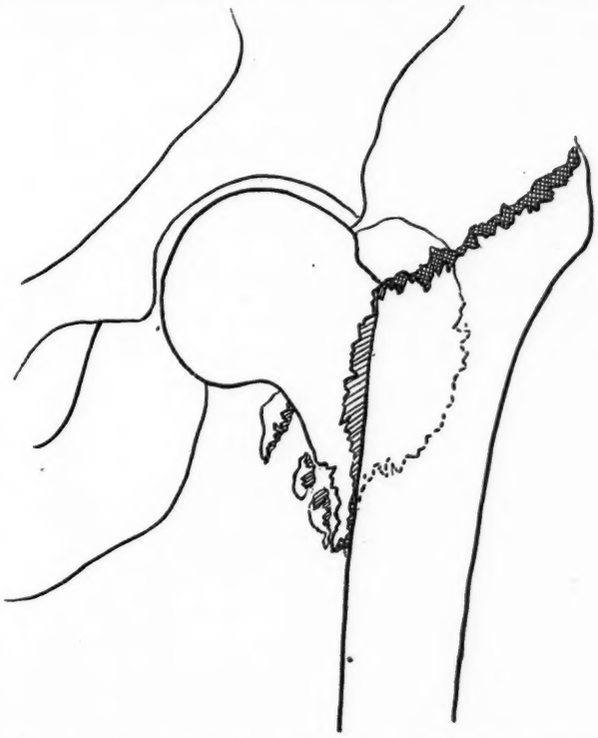

Fig. 21. Another instance of great shortening. The indication to extend and then abduct the shaft of the femur in treatment is plainly indicated.

Fig. 22. Reduction obtained in the usual fracture of 2 fragments. Note the restoration of the neck angle and the length acquired with the abducted position of the thigh.

Treatment: Incomplete intertrochanteric fracture calls for rest in bed for a couple of weeks. No weight should be borne for three to four weeks. Hot applications on the hip relieve pain and swelling.

Complete fractures, which show a change in the angle of the neck of the femur, require proper immobilization. The indications to be met in the treatment are:

Slight shortening—

Adduction of the leg—

Reduction in the angle of the neck.

Because the plane of this fracture has passed through cancellous bone, we can anticipate a bony union in practically every case, even following a short rest in bed with little immobilization. Our series verifies this fact. To satisfy the indications given, we should extend the leg by traction and while it is under tension abduct it to the maximum, turn the foot slightly inward and place the patient in a body cast, such as is used for fracture of the neck of the femur. This cast need be worn but six to eight weeks. The patient can then become ambulatory, wearing a walking caliper for six weeks to take

Fig. 23. Reduction of a comminuted intertrochanteric fracture. The loosened trochanters fail to follow the shaft. A position half flexion of the thigh combined with abduction aids reduction of this separation.

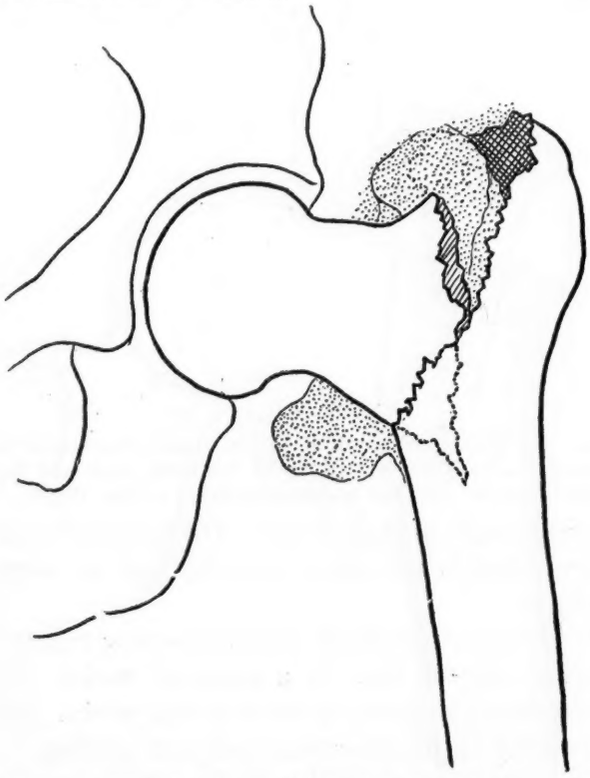

Fig. 24. Complete impacted fracture healing in an unreduced position. Callus rapidly filling in. Extension and abduction required to restore length and neck angle. This case resulted in 1¼ inches shortening and limited hip motion.

Fig. 25. Complete fracture healed in malposition. Abduction alone would have promised a fair reduction of this fracture. Note the abundant callus. The permanent neck angle here is about 90°.

Fig. 26. Complete fracture healed in malposition. Note the huge callus and neck angle less than 90°. This type of union leads to a maximum shortening and loss of function of the hip joint.

weight off the young callus, moving his hip while not bearing weight. (Figs. 22 and 23).

Old individuals who for any reason cannot tolerate a plaster of Paris cast, may lie in bed propped on pillows or possibly submit to a Buck extension for a few weeks. There is practically never indication for open operation on an intertrochanteric fracture of the femur.

Results: The mortality under all treatments is as given. The average result is a bony union. If extension and abduction have restored the fragments to proper position, we can expect no shortening. There is usually some restriction of hip motion, no matter how perfect the reduction of framents. When proper reduction and immobilization has not been followed, we may expect shortening up to one inch, seldom more, considerable excess callus which leads to restriction in hip joint function, and some adduction of the leg on account of the change of neck angle. Bony union, however, permits weight bearing and a fair function to these old people. (See figs. 24, 25, 26). Incomplete fractures give excellent results after six weeks.

Note—Each illustration of fracture is made from the tracing of the roentgenogram of an actual case, selected by the author.

122 SOUTH MICHIGAN AVENUE.

After all, the localization of bone tenderness is not only the most useful sign in determining the site of a fracture, but, even in the absence of other signs, it is often, in itself, diagnostic of the presence of a fracture. As instances may be cited greenstick fracture of the clavicle, and fracture of the metacarpal and metatarsal bones.

CANCER RESEARCH

Cancer research will be taught at Columbia University during the Summer Session. The course will be given at the Crocker Laboratory, 1145 Amsterdam Avenue, and will deal with the morphology and biology of tumors, under the direction of Prof. W. H. Woglom of the laboratory staff.

The instruction will consist of a series of lectures and laboratory exercises, and is intended to give the student sufficient experience to enable him to diagnose all the commoner varieties of tumors. It is planned especially for the needs of those who are to take up hospital or public health laboratory positions which may require the microscopic diagnosis of tumors.

STANDARDIZED TREATMENT OF FRACTURES OF THE LEG.*

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Professor of Surgery, New York Post-Graduate Medical School and Hospital.

For descriptive purposes and in accordance with clinical findings we may regionally divide fracture of the leg into three zones of incidence: an upper, middle and lower.

The *upper third* zone includes fractures of the tibial and fibular head, the tibial tubercle and the adjacent portion of the upper end of the tibia and fibula, not excepting the very rare fracture of a tibial spine.

The *middle third* includes the central portion of the shaft of both bones.

The *lower third* comprises both malleoli and the shaft portion immediately contiguous.

In a broader classification we may regard the leg as being the site of fracture in its articular and in its shaft portions. More broadly yet, we can say that from a clinical standpoint we encounter fracture of the leg below the centre of the shaft in approximately 80% of cases, this including the average shaft fracture and the very frequent fractures about the ankle.

For the purposes of this article, reference will be made only to typical examples of fracture in the zones already indicated.

There are certain considerations in fracture of the leg that have a special bearing as to diagnosis, prognosis and standardized treatment, and of these I would mention:—

(1) The frequency of non-union in fracture of the lower third of the tibia. In my experience there are more cases of non-union in this location than of all other fractures combined.

(2) The almost total absence of non-union in fracture of the fibula, even in the presence of marked over-riding or gross deformity. I do not recall having seen a case of non-union in this bone. The fibula has an unusually large nutrient artery.

(3) The rarity of non-union when the articular ends are involved (detached marginal fractures excepted). Clinically we observe that articular fractures in all locations usually end in bony union except fractures of the neck of the femur.

(4) Compound fracture of the leg is more prone to infection than any other compound fracture,

*From the Department of Traumatic Surgery, N. Y. Post-Graduate Medical School and Hospital.

mainly because the tibia is sub-cutaneous, with stasis of circulation acting as a contributing factor.

(5) Blebs are more frequent in leg fractures than elsewhere and they are often massive and numerous.

(6) The position of the external popliteal (peroneal) nerve winding around the head of the fibula makes this a danger zone because pressure from splints or apparatus invites foot-drop.

(7) The frequency with which a long oblique fracture of the lower third of the tibia is associated with fracture of the upper end of the fibula; this fracture is due to torsional violence, and when separation of the tibial fragments is marked, there is a great tendency toward muscular impingement leading to non-union.

(8) Many cases of ankle injury with gross eversion and posterior deformity are still looked upon as dislocations despite the fact that Sir Percival Pott disproved this possibility nearly 125 years ago.

Irrespective of the cause, site or variety of a fracture of the leg, we recognize that in reality there are but two clinical types, either of which may be simple or compound:

Type I is the *displaced variety* in which the fragments are markedly separated.

Type II is the *non-displaced* variety in which the fragments are slightly separated.

This "typing" applies also to fractures of any other part of the skeleton and is of importance because in Type I the essentials of treatment are reduction and retention; but in Type II, only retention is necessary.

It is important to remember also that the bone injury is only one part of the pathology of any fracture and that the associated lesions may prove equally important because they affect the soft parts (myotenosynovitis), the articulations (synovitis, bursitis, arthritis) and the vessels (vascular and neural).

DIAGNOSIS.

The Type I cases present no difficulty. They are apparent to the sense of sight as deformations and the only differentiation is as between articular fracture and dislocation. In this connection it is helpful to remember that about 80% of so-called dislocations of the knee and ankle prove on later examination to be fractures. In Type II differentiation is as between non-displaced fracture and contusion-sprain; and this becomes apparent to the sense of touch which determines the presence or absence of local pain. If the latter can be demonstrated by direct or indirect pressure, a diagnosis of fracture is warranted.

TREATMENT.

An attempt is made to standardize and make uniform our procedure and with that in view, the respective non-compounded types are treated as follows:

Type II—all zones. Two-piece antero-postero moulded plaster of Paris cast reaching from the toes to 6 inches above the knee. If the fracture is at or below base of malleolus, the splint does not include the knee. If the fibula alone is broken,

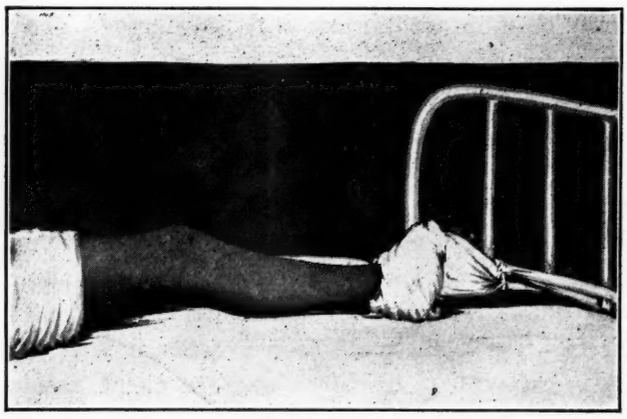

Fig. 1. Temporary traction by towel or sheet.

only the posterior half of the cast is used—the so-called "slipper splint".

Type 1—all zones. If reduction can be made effectual by immediate or prolonged traction (i. e., by weights, straps or on a fracture table) then the case has been converted into Type II and treatment is as above indicated. If, however, reduction cannot be effected by manual traction,

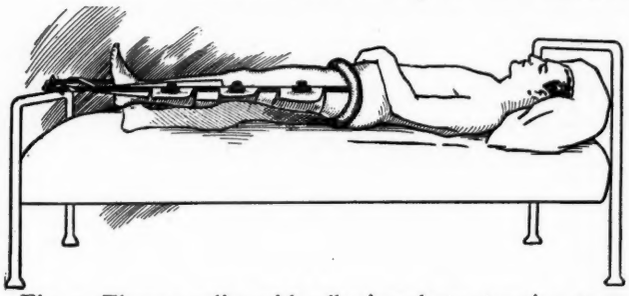

Fig. 2. Thomas splint with adhesive plaster traction straps.

by sheet or towel traction or by straps with or without a Thomas splint (fig. 1.) and the overhead (so-called Balkan) frame (fig. 3), then the case falls into the group I denote as the "irreducibles" and some form of operation becomes necessary. Hitherto the procedure has been open reduction by operative exposure of the fracture site, but in my experience this has not been necessary since resorting to "skeletal traction" as effected by the use of the Finochietto stirrup, (fig. 4.) the tongs (calipers),

or transfixion by the nail. Of these my preference is for the stirrup passed over the os calcis (figs. 4 and 5), or the tongs thrust into the malleoli (fig. 6).

The use of non-absorbent material (plates, wires, screws) is deservedly falling into disuse and my be-

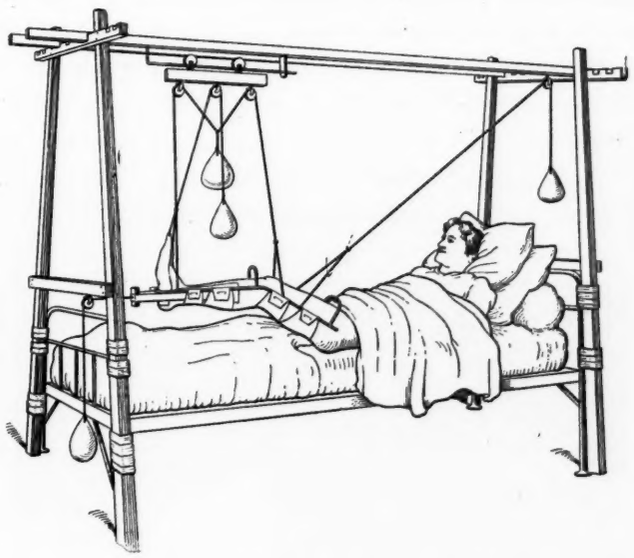

Fig. 3 Fracture of the leg. Hodgen splint and overhead suspension frame, Blake type, adhesive plaster or glued flannel traction straps along leg. Note the glued sock attached to cord and weight to prevent foot-drop. Knee is flexed at an angle of about 135 degrees.

lief is that in another five years plates will be as rarely used as wooden handled instruments.

Compound fractures are treated, after tetanus

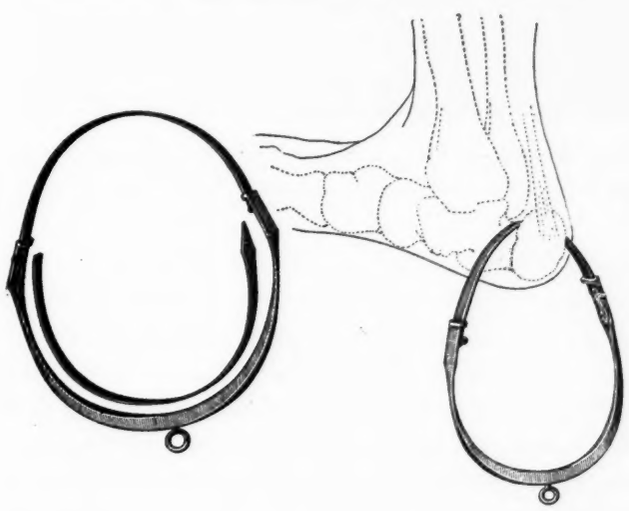

Fig. 4. Finochietto stirrup and method of obtaining traction by passing it over the os calcis.

antitoxin injection, according to their severity, as follows:

Mild—with punctured wound. Iodine disinfection through a syringe. Iodine-saline wet dressing, (iodine one dram, saline solution 1 pint).

Moderate—with lacerated wound. Iodine sterilization, débridêment, partial suture or delayed suture, Iodine-saline dressing.

Severe—with crushing wound. As above. Delayed suture preferable in 3-6 days.

If, however, *immediate* reduction is impossible by the preceding means, then *intermediate* reduction is to be employed by means of weights attached to the limb by adhesive plaster or glued strips of flannel. The knee is flexed (15°—30°), the foot of the bed is

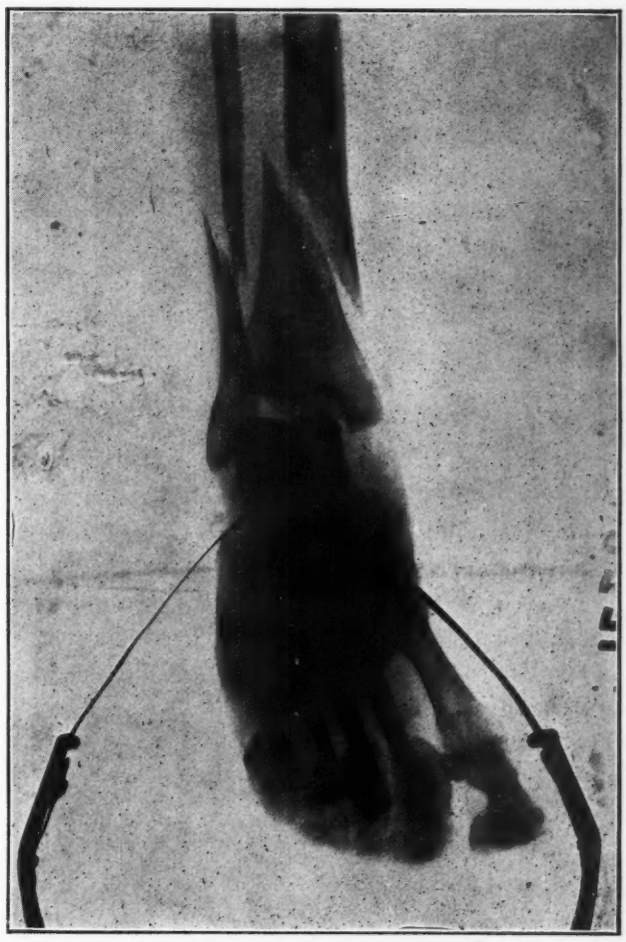

Fig. 5. Supra malleolar fracture of the tibia and fibula. Reduction satisfactory. Finochietto stirrup in situ.

elevated and the limb is placed in a Thomas or Hodgen splint, or some form of inclined plane, and slung to an overhead frame of the so-called "Balkan" type. Massage and motion are given from the outset. This apparatus is employed until union is firm and then an antero-postero moulded plaster of Paris splint is substituted, this reaching from the toes to above the knee. The front half of this is removed frequently for massage and motion. Another plan is to apply a "walking calipers" (fig. 5) instead of the 2-piece plaster of Paris splint as this permits walking with all the advantages of ambulatory treatment. It will be noted that nothing is said as to a

circular plaster of Paris cast because this type of splint often acts as a tourniquet, it hides the parts, it prevents massage and motion. Hence it is not only dangerous but is also a foe to early return of function. In compound fractures a splint of this encircling type is particularly inferior to the traction methods or to the two-piece splint. In all forms of traction, the direction of pull is that of the *upper*

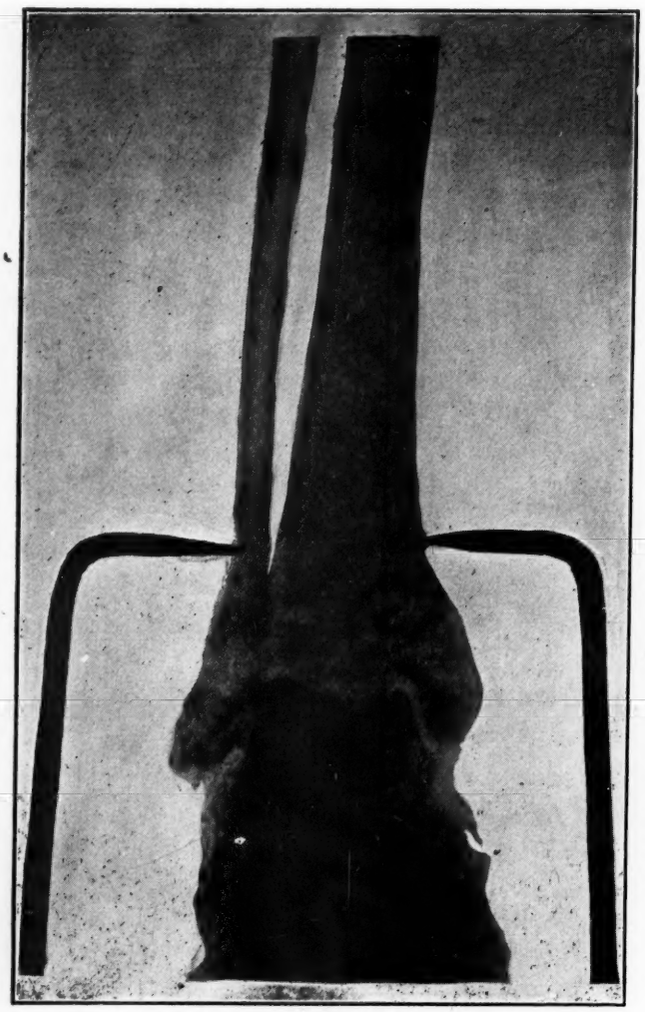

Fig. 6. Tongs applied to malleoli for fracture of leg. Note that depth of penetration in subperiosteal.

fragment and counter-traction is best obtained by elevating the foot of the bed. It is prudent to employ 10-20 pound traction weights at first so that muscle spasm may be early overcome; once this is accomplished, a weight of 5 pounds suffices.

It cannot be too strongly insisted upon that we *set* a fracture not by *setting* the bone, but by *setting* the muscles which maintain bony mal-alignment.

In *Pott's fracture* there exists, practically, a fracture-dislocation, inasmuch as the entire foot is displaced outward and backward because of the upset of the concavo-convex junction between the under surface of the tibia and the upper surface of the astragalus. It is important to remember that marked types of that fracture may show displacement of the interosseous malleolus (lower outer end of tibia) in addition to the classical fracture of the fibula and the laceration of the internal lateral and interosseous ligaments. The key to treatment is the restoration of the tibial-astragalus concavo-convexity and unless this see-saw arrangement is restored, the architecture of the joint will be compromised and functionally impaired.

To properly reduce a Pott's fracture, anesthesia is necessary and for this purpose nitrous oxide, ether

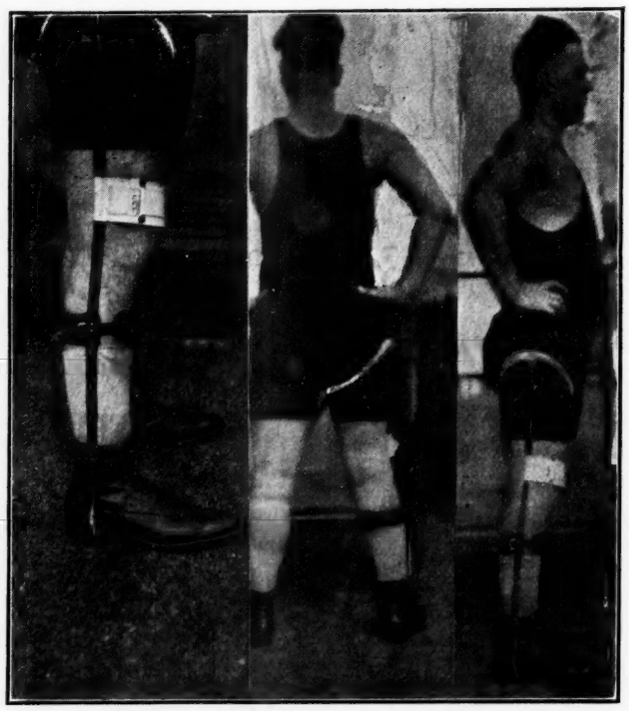

Fig. 7. The "walking calipers" for ambulatory treatment and for use after union is reasonably firm. This is essentially a Thomas splint with the lower end fitted into the heel.

(by the drop method) and ethyl chlorid (on the mask) are the safest in the order named. Chloroform is particularly dangerous in fractures and dislocations; indeed this agent is as dangerous in traumatic surgery as it is safe in obstetric surgery. Relaxation of the tendo Achillis is the next essential and hence folding the thigh fully on the abdomen is the proper posture before reduction is attempted. Next the foot should be firmly grasped and the deformity *markedly increased* up to the point of obtaining very free false motion and crepitus. Then slow and gradual downward traction is made until a sensation of "giving" is felt. Next the foot is brought as far forward (flexion) and inward (inversion) as possible. If the correction is satisfactory, (1) the

bony deformity disappears; (2) the malleoli are on the proper level; (3) pressure of one finger against the sole holds the foot at a right angle (Jones' test). A loop of a bandage is then placed around the big toe and the free end of this is given to an assistant until the patient is out of anesthesia or the splint is in place. A two-piece moulded plaster of Paris splint is now applied—the Stimson splint. The posterior portion of this 4-inch wide strip passes from the web of the toes, along the sole, over the heel and up the back of the leg to the lower part of the popliteal space. The lateral 4-inch piece begins over the inner malleolus, crosses the instep, passes under the sole (surmounting the posterior part of the splint) and goes up the inner side of the leg as high as the other part of the splint. A bandage holds both sections of this postero-lateral plaster mould, and the anterior half is removed daily or less often for massage. The outer portion of the leg is thus free for inspection and circulation.

Passive motion of the ankle begins within the first week, active motion about the tenth day, the ankle being held during the early phases of this part of treatment. In no fracture is *early mobilization* so important, otherwise organized exudate from associated synovitis, arthritis and myotenosynovitis will produce stiffness despite accurate bony readjustment. The lateral half of the splint can be removed as soon as union is relatively firm and when active ankle motion causes no reaction. This is ordinarily at the end of a fortnight, and thereafter the posterior part of the splint is gradually shortened so that it is all off by the end of the fourth week. Adhesive strapping or a linen-mesh bandage is then substituted and walking on the *flat of the foot* is allowed when pounding on the heel or firm pressure on the sole is painless. The patient is made to toe-in at first so that eversion is prevented; in some cases building up of the inner side of the sole and heel will aid in this element of treatment.

There is another group of fractures of the shaft of the tibia and some supramalleolar fractures in which the preceding immediate or intermediate methods of reduction are unsatisfactory. These are certain compound fractures and others in which the displacement is very irregular, such as the long oblique much displaced type, or particularly fractures of the lower third with much mal-alignment. This group I term the "irreducibles", and formerly operation was the necessity so that coaptation was accomplished by some form of suture, such as kangaroo tendon, wire, screws, bands, plates or other interposed materials. The use of non-absorbable materials has justly fallen into disfavor because of their danger as to life and limb, their tendency to cause non-union and osteomyelitis. Personally, I have not found it necessary to plate or wire a fracture in a decade, and this form of treatment is not needed if for it is substituted *skeletal traction*. The principle of treatment here is that alignment is obtained by introducing a 3-16 inch nail through the malleoli or os calcis (Steinmann transfixion method); or by placing tongs or calipers on the malleoli or os calcis (Ransohoff tongs or calipers method); or by passing the band of a stirrup over the os calcis in front of the tendo Achillis (Finochietto stirrup method). The traction thus obtained is *direct or internal* as opposed to the *indirect or external* method represented by other forms of traction. Of these forms of skeletal traction, the tongs or stirrup are most useful in leg fractures, and the nail in femur fractures. There is little or no danger of bone infection and the skin infection is negligible. These traction devices can be introduced under local anesthesia and removal to the hospital is not necessary. Reference to the diagrams will sufficiently indicate the procedures, which I have described at length elsewhere. When union is firm, the traction appliance is removed, the two-piece plaster of Paris antero-postero splint is substituted, or the "walking calipers" is employed. Under this form of treatment I feel certain that non-union will be less frequent, deformity will be lessened, joint stiffness minimized.

Non-union, if resistant, is best treated by bone grafting, either in the form of the sliding or socketed graft taken from the same leg, or a graft from the opposite leg. If there is no great displacement, a periosteal-cortical graft will often supply the necessary bony transfusion as effectively as a periosteal-cortical-medullary graft, plus the additional advantage of an operation easier for the patient and the surgeon.

Mal-union demands open osteotomy (refracture), the removal of osseous spurs and the application of skeletal traction; some early cases will respond to closed osteotomy and skeletal traction.

The radiograph of the elbow of a child shows shadows of numerous epiphyses. One inexperienced with *x*-ray plates is very apt to mistake one or more of these for fractures. When examining the skiagraph of a child's elbow suspected of fracture or dislocation, it is, therefore, important to have the normal picture in mind, or better yet in hand, for comparison.

TREATMENT OF ANKLE FRACTURES.

FREDERIC J. COTTON, M.D., F.A.C.S.,
BOSTON.

Ankle fractures are common, do not do uniformly well, offer a considerable variety of complications, and are therefore interesting, in spite of the fact that the problems involved are intrinsically rather simple.

The diagnosis is *made* by eye and hand, *confirmed* by the *x*-ray examination. *Reversing* this order in diagnosis is the reason of most of the calamities that are not very uncommon even today.

There are five main types. Each type has its own definite reduction maneuver.

To treat these cases one *must know the types* and must be mechanical-minded, and not without some skill of hand.

The types are:

1. Fibula fracture.
2. Pott's fracture.
3. Inversion Pott's fracture.
4. "Cotton's fracture".
5. Fracture of both bones above the ankle.

Breaks of both bones, slanting down into the joint, and separations of the epiphysis of the tibia are, mechanically considered, but variants of type 5.

TYPE I, fibula fracture, is the result usually of an inward twist, a "turning" of the ankle. Such a twist, if slight, produces a "sprain". In a sprain the tendons are stretched, and the ligaments between tibia and fibula are torn a bit, often torn away from bone enough to show later in the roentgenogram by a bit of new growth of bone. A bit more twist is too much for the fibula and it cracks, usually above the joint, usually on a slant up and back.

If there is, in addition to the signs of sprain, definite tenderness across the surface where the fibula is subcutaneous, one may be pretty sure the bone is broken. If, with this condition, there is no clear sign of damage about the inner ankle, no displacement possible, in, or out, or back, on reasonable forced pressure, one may be pretty sure nothing else is gone.

With fracture of the fibula alone, one merely shoves forward on the lower fragment to get the best contact possible (and it really matters not at all if this is not very exact) and then puts the foot up in plaster for three or four weeks, then protects with adhesive strapping.

It is but a trivial injury.

TYPE II. If one adds to the above picture ecchymosis and swelling and tenderness on the *inner* side, and either an outward displacement of the foot, or a condition in which the foot is readily displaced *out*ward, then one has to deal with a *Pott's fracture.*

The injury at the inner side is a breaking off of the malleolus or a tearing away of ligaments;—in either case the lesion is serious,—serious because it is essentially an *outward luxation* of the foot. (See fig. I, A).

Prompt reduction of the luxation is essential.

Primarily compound fracture is not common, but it is not very uncommon, in neglected cases, for the skin over the sharp edge on the inner side to slough, with disasterous results.

Reduce, therefore, and hold the reduction even if

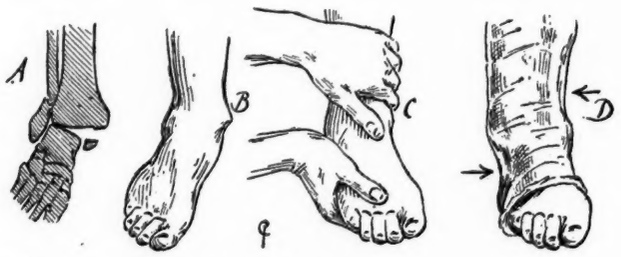

Fig. 1. Type 2. Pott's fracture.

A. Bone lesion: Fracture of fibula. Either fracture of malleolar tip (as shown) or a tearing of ligaments only, on the inner side, below the malleolus.

B. External deformity, *outward luxation* of the foot as a whole. Usually a spur-like projection at B.—the lower spade-like edge of the intact tibial shaft from which the broken piece has been torn away and displaced outward.

C. Reduction. Pull *outward* above the ankle, push the foot *inward*. *Over-correction is impossible.*

D. Retention: Loose plaster of Paris bandage over padding. Before setting of the plaster, go through reduction motions again, pulling out above the ankle, shoving the foot inward, as the arrows show, and hold pressure in and out at these points until the bandage has "set". Keep the foot at right angles.

a second setting is needed after checking up with the *x*-rays.

Reduction is easy and is accomplished by swinging the foot *in*ward until it is corrected. One *can not over-correct; if the foot can be over-corrected the diagnosis is wrong!*

It is right enough to carry the foot inward, into supination a little, to maintain full correction; extreme inversion, as carried out in the old "long Dupuytren" splint, is painful and needless.

Union always occurs, I think, and the two cases of ununited internal malleolar tip, the one case of overlong internal malleolus that I have seen, were obviously the result of lack of protection in early convalescence.

The danger in this particular lesion is of flat-foot, of which more later.

TYPE III reverses the lesion and the displacement. The lesion is called inverted Pott's, inversion Pott's, or reversed Pott's fracture. The fibula is broken *not above, but at the joint,* the internal malleolus not near its tip but from the joint-angle *up and in,* often with separation of a considerable piece of bone.

The *x*-ray picture looks a good deal like that of a true "Pott's" fracture—in a general way.

It should be pounded into the head of every interne that a fracture of both malleoli *may* or *may not* be a Pott's fracture. I have repeatedly seen in my own hospital lamentable messes due to the error of confounding Pott's and inverted Pott's fractures.

The story is not one of the bone lesion as such.

Fig. 2. Type 3. Inverted Pott's fracture.
A. Bone lesion. External malleolus torn away, internal malleolus split up and carried *up and in. Inward* dislocation.
B. Deformity. Inward dislocation.
C. Reduction. *Inward* push above ankle, outward pull on foot. *Over-reduction impossible.*
D. Retention in plaster of Paris. Repetition of reduction with retention of shove and pull, as the arrows show, until the plaster has set. Keep the foot at a right angle.

The important thing is that an inverted Pott's fracture is an *inward dislocation,* reducible by abduction, made worse—and very bad—by the very reduction properly applied to type 2.

Diagnosis is easy. In type 3 the foot can *easily* be carried *inward* into *obviously abnormal inversion.*

The reduction is *outward;*—here again one *can not over-reduce;* the position to be maintained is moderate *pronation.*

The danger in this type is not the development of flat-foot, but non-union of the inner fragment—a not very rare calamity, enjoining on us an extra period of protection in this type of cases.

TYPE IV is the *backward* luxation, associated with fracture of both malleoli and a *splitting off of the back edge of the tibia.* Recognized before, of course, these cases seem to have been grouped as a type for the first time only a half-dozen years ago.*

Backward displacement without this break in the back edge, is distinctly rare.

*Cotton: *Journal Am. Med. Ass'n,* January 23, 1915, LXIV, p. 318.

The lesion now under consideration is so common that in my first report classifying this fracture* I was able to cite 53 cases of my own,—and I have been seeing them ever since.

The diagnosis of this "Cotton's fracture" is easy enough. Usually obvious to a trained eye, the backward displacement may be verified more exactly by the projection of the lower edge of the tibia in front above the ankle joint. (see fig. 3, B).

If the displacement has already been reduced, the condition is obvious from the ease with which the foot drops back into dislocation on handling it.

Here again one reduces "the way it came out" but not always as readily as with types 1 and 2.

Fig. 3. Type 4. "Cotton's" fracture.
A. Bone lesion. A piece split away from the back edge of the tibia. Also fracture of both malleoli. (Some times back-edge of tibia and internal malleolus go in one piece). Primarily a backward luxation with fractures.
B. Deformity. A *backward displacement of the foot.* There is usually a sharp prominence of the lower front edge of the tibia in front, above the displaced foot—if one feels for it!
C. Reduction. Backward pressure on front above ankle, then a forward pull, downward at first, then up and into dorsal flexion—to lock.
Retention calls only for maintenance of dorsal flexion in plaster.

Let the foot drop into plantar flexion, then *drag* it *down* and *forward* into place, and bring it up into *forced dorsal flexion.* In this position it *locks* solidly in place, and there is little difficulty in holding correction in plaster.

TYPE V is in fact no type. It is like the "type 4" of pneumonia,—anything that isn't the other things—and no real rules can be given.

Here, not as with the other four types, one needs the *x*-ray finding before doing anything real in treatment or even in diagnosis. If we have a cross-break or an epiphyseal separation we need only reduce and put up in the neutral position.

This same procedure may suffice with breaks slanting into the joint, or we may have to hold them with special pads, or with special pressure outside the plaster, or may at times have to resort to open operation.

If there is comminution, simple plaster may serve,

or we may need traction in splints (the old "short Dupuytren", with traction two ways, is not bad) or traction in combination with plaster, or (rarely) open operation may be resorted to. There are no rules that will cover. Fortunately, these cases are apt to do well if decently replaced with a proper eye to *weight-bearing lines,* and the delayed union common in the fractures between middle and lower thirds is not common close to the joint.

ITEMS IN TREATMENT.

1. *X-ray examination.* Always to be made, but in types 1—4 it may be wise to reduce first, and

Fig. 4. Boston City Hospital "Pillow and Side Splints." To be genuine, one should use tied bandages. Buckle straps, rather more efficient, seem to offend precedent.

always one should reduce promptly, roentgenogram or no roentgenogram, if there is great displacement, even if this does not threaten sloughing.

Delay means too much suffering and probably too much tissue reaction.

2. When is *immediate plaster of Paris dressing* advisable? Usually in type 1; and in the other types if there is little reaction. If in doubt use the old Boston City Hospital dressing of "pillow and side splints", shown in Fig. 4. It is comfortable and may be made to hold any of these fractures adequately for a time. But *do not put unreduced luxation-fractures up in this way* or in any way until they are brought into at least *decent* position.

3. *Blebs.* These often appear in ankle fractures. They are to be treated by alcohol sterilization of the surfaces then alcohol dressing (1 part to 3) and they are to be opened when full. The alcohol dressing, continued, carries them by the chance of sepsis, and

Fig. 5. Outside upright. Steel half circle at top, completed with leather strap. Ankle joint. Inside "T" strap fastened to shoe at inner edge of shank, just at front end of the heel, buckling around the upright on the outer side, just above the ankle.

presently a dry dressing with zinc stearate powder makes possible the handling needful for a real reduction, with subsequent plaster of Paris splinting.

4. *Splints.* Uniformly inferior to plaster of Paris save for certain cases of type 5. If a splint is to be used I always prefer the Cabot "posterior wire" splint with flat side splints as needed. This gives easy access for inspection and change of pads or for dressings.

5. *Technique of plaster application.* The best way is to reduce first, then wrap the leg in a moderate covering of sheet wadding, then put on the plaster bandages, not tightly, but *rolled on.**

One tries to maintain reduction throughout, but the important thing is that *after the plaster is on* before it sets, one carries out again the reduction found effective in this case, and then keeps up pressure with the hands in the proper places so as to *maintain* reduction. (note arrows in figs. 1, 2, 3).

6. As above noted, *over-correction* of the deformity is impossible in cases types 2, 3, and 4.

7. *Right-angled dorsal flexion* is always to be maintained if possible.

8. *Time of leaving plaster on*:

3 weeks for type 1.

4-5 weeks for type 2.

4-6 weeks for types 3 and 4.

and in type 3 even longer if needed for consolidation of the inner fragment.

9. *After-care and apparatus.*

In type 1 adhesive strapping as for a sprain (Cottrell-Gibney technique) up to the sixth week. Weight-bearing after four weeks. Special caution not needed in average patient.

In type 2, plaster split at 3-4 weeks; massage and motion begun then. Plaster off at 4-5 weeks, and foot then put into a shoe with outside upright, ankle joint and T-strap (see fig. 5). Full weight may be borne after six weeks, and exercises as for flat-foot begun then.

The apparatus may wisely be worn up to four months. If exercises are well done, plates are rarely needed after this but a quarter-inch raise on the inner edge of the heel may often be wise for a while after discarding the brace.

In types 3 and 4 I am apt to use the *double* upright on the shoe, with the ankle joint stopped at first with a pin (which can be knocked out later) and which for the time holds the foot at a right angle. Weight-bearing and exercises are the same as for type 2. Bear in mind, however, that one must go slow with type 3 until certain of union.

Late cases come to us, unfortunately, badly crippled. Those of type 2 may have only flat-foot amenable to treatment for that.

If they have actual displacement there is nothing for it but the bi-malleolar osteotomy described by Stimson. Most important to remember in these operations is that we must not only cut the malleoli but must cut or tear much ligament to get real reduction. Properly reduced, and well held in plaster after reduction, these operative cases do well.

Old cases of type 3 also call for osteotomy of the external malleolus. To the inner side one more often needs to refresh surfaces of the ununited fracture. I have found it wise to pin this fragment in place with a steel pin that stays in three weeks. Results have usually been good.

In type 4 one may do bi-malleolar osteotomy and forcibly lever* the foot into place onto the remaining portion of the tibial articular surface.

Reproduction of the old fracture is not practicable.

If there is too little joint surface left, with a joint stable enough, but crippled because of fixed plantar flexion, this may be dealt with by cutting the front part of the tibia away—liberally.

Results of both operations are much better than one would think, considering the complicated lesion.

In conclusion, may one say that all that is not old in this brief summary is a somewhat sharper division into types; recognition that each of three of the types is essentially a luxation with fractures as complication only; sharper definition of the reduction maneuvers for each type; insistence on early function; insistence on a protection by apparatus not usually used, both to ensure this early function, and to safeguard against the late complications that not uncommonly spoil even those cases of ankle fracture that have been reduced properly at the start.

*Stimson strip plasters are excellent in many cases but are distinctly not for the novice in plaster work. Personally, I have found the Stimson method of no special use save as furnishing a lighter support, effective enough for the simple fibula fractures.

*I use a heavy smooth automobile tire-iron, of the old-fashioned type—about 18 inches long.

FRACTURE OF THE HEAD OF THE RADIUS.

Fractures of the head of the radius are frequent and are often unrecognized.

The two most common types are a split extending downward into the neck and shaft of the bone and a crushing of the anterior lip.

The cause is not definitely determined.

The diagnosis can usually be made by the muscular spasm which accompanies rotation and this is present in all cases.—L. E. DOUGHERTY in *Minnesota Medicine*

Fractures of the head of the radius are probably more common than generally supposed, being overlooked frequently because of the absence of the ordinary signs of fracture.

Permanent contracture of the muscles, notably of the flexor group in the forearm, may develop within a very short time after the application of a splint that exercises undue compression. It is a wise rule to inspect all fracture dressings within twenty-four hours; and when this is not expedient special care should be exercised, when applying the dressing, to avoid compression.

POTT'S FRACTURE OF THE FIBULA, OR FRACTURE-DISLOCATION AT THE ANKLE.

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The term "Pott's fracture of the fibula" is and has been so loosely applied to fractures about the ankle joint, that it is quite impossible to know in any given case what the actual injury was, without a careful description of the lesions.

The following is the description given by Percival Pott, of the series of injuries which make up the complex that goes by his name:*

"This is the case when by leaping or jumping, the fibula breaks in the weak part already mentioned; that is, within two or three inches of its lower extremity. When this happens, the inferior fractured end of the fibula falls inward towards the tibia, having lost its proper support, and not being itself capable of steadily preserving its true perpendicular bearing, is forced off from the astragalus inwards, by which means the weak bursal or common ligament of the joint is violently stretched, if not torn, and the strong ones which fasten the tibia to the astragalus and os calcis are always lacerated, thus producing at the same time a perfect fracture and a partial dislocation to which is sometimes added a wound in the integuments made by the bone at the inner ankle."

This paper is intended to treat of the injury thus described by Pott, which I should prefer to call a dislocation of the ankle joint with fracture of the lower third of the fibula. As a matter of fact, the internal malleolus is not infrequently broken off, sometimes but not frequently by any means, a small part of the external rim of the articular surface of the tibia is also fractured.

The essential features to remember and to recognize in the treatment are: 1. The dislocation of the tibio-astragaloid articulation. 2. The fracture in the lower third of the fibula.

In order clearly to understand this injury, one must have in mind the configuration of the lower ends of the leg bones and the astragalus and os calcis —in other words the make-up of the ankle joint and its immediate connections.

A reference to the diagram, fig. 1, will assist in understanding the points I wish to make. In the first place the ankle-joint is not a tenon and mortise joint as is so commonly stated. It is much more of a condyloid character. The upper (transversely fairly oval) surface of the astragalus fits into the oval space made by the malleoli on either side, and the hollowed-out lower extremity of the tibia. The fibula fits into a shallow groove in the outer articular rim of the lower end of the tibia and it is held firmly against this part of the tibia, not only by the interosseous membrane, but also by a special ligament, the tibio-fibula ligament. While some motion between the lower ends of these bones is possible, they are held together by very strong fibrous bands. Both malleoli are connected to the astragalus and calcaneum by ligaments. The inverted V-shaped ligament from the fibula side is longer, slenderer and much weaker than the connection on the internal malleolus or tibial side, by the broad powerful internal ligament, which extends not only to the astragalus but also to the side of the calcaneum.

Fig. 1. Diagram of a section through the ankle-joint vertically to show the bony surfaces and primary ligament.

The muscles chiefly concerned in this injury have narrowed to tendons at the point usually traumatized. Those on the inner malleolus side are the posterior-tibial tendon and the flexor longus digitorum which run in separate sheaths through the posterior groove in the malleolus, and behind these is the tendon of the flexor longus pollicis. Between the two last tendons run the posterior tibial vessels and nerve.

The tendo Achillis, which terminates the most powerful double muscle of the leg, is inserted posteriorly into the apex of the heel bone—the calcaneum, is superficial to and behind the flexor longus digitorium. On the outer side are the two peroneal tendons in the groove behind the external malleolus. In the mechanism of the injury these last, I think, play no important part.

*The Chirurgical Works of Percival Pott, F.R.S., 1st American Edition, 1819, p. 248.

THE CAUSE AND THE MECHANISM. PHYSIOLOGIC FEATURES OF THE INJURY.

In nearly all cases Pott's fracture is caused by the individual falling or jumping and landing on his feet or foot. As a matter of fact, in a jump or fall that results in this serious injury the subject does not land squarely on both feet, but is deviated a little to one side, and the momentum comes chiefly in one foot, and outwardly. In other words, the force is so applied that one foot is violently everted and abducted. I think the first effect is a dislocation of the tibio-tarsal joint, laceration of the internal lateral ligament, and laceration of the tibio-fibular ligament, and perhaps a fracture of the tip of the internal malleolus. If the force continues, the foot will be turned so violently outward that the leverage will produce a fracture of the fibula two to three inches from the tip of the external malleolus. The gastrocnemius then draws the heel backwards and upwards, thus causing the articular surface of the astragalus to dislocate backwards. The inferior end of the tibia will then be outwards and forwards; this produces an apparent shortening of the foot.

From this regular (as it may be called) condition of affairs, there occur many variations. I have seen cases in which the inferior end of the tibia was driven backwards and outwards and rested just under the violently stretched skin with the posterior tibial and flexor longus digitorum tendons in front of it and the flexor longus pollicis behind it. In other words, the end of the bone had gone between the tendons and, of course, had badly injured, though it had not severed, the bloodvessels and nerves in the malleolar space. Another variation in the dislocation that I have seen, was the astragalus driven up between the leg bones. The fracture of the fibula was higher up in this case than usual. I cannot recall any case of internal dislocation of the tibia at the tibio-astragaloid articulation with fracture in the lower third of the fibula. This kind of an injury might result from direct violence, however. Such cases have been reported. I have seen many cases of fracture of the fibula in its lower third, laceration of the internal lateral ligament, sometimes with fracture of the tip of the internal malleolus, without any appreciable dislocation at the tibio-astragaloid joint. These cases, undoubtedly, had at the instant of the injury a partial dislocation at this joint, restored by some fortuitous twist of the body or violent contraction of the leg muscles.

A classical Pott's fracture is, then, a partial dislocation of the tibio-astragaloid articulation, (of course serious laceration of the internal lateral ligament occurs, sometimes a fracture of the sharp part of the internal malleolus also takes place), and fracture of the fibula in its lower third. The foot is in abduction and everted. The tibio-fibular ligament is torn. The external malleolus does not leave the side of the astragalus as a rule, and the astragalus is driven relatively far outwards; this pushes the internal malleolus outwards, also tips the superior extremity of the distal fragment of the fibula inwards against the side of the tibia, thus separating the two fragments of the bone very considerably.

The inferior end of the tibia is pushed outward and forward against the superficial soft tissues so violently that they are frequently broken, and a compound fracture results. In ordinary cases the lower tibial extremity is pushed outward and forward and rests just under the skin, which is stretched tensely. The pressure of the ends of the bone against the skin is exceedingly painful. This causes violent contraction of the muscles, so that all the tendons about the ankle joint become rigid cords. The foot, fixed in its false position by the tetanic spasms of the muscles and jamming of the articular surfaces, is very rigid, and all attempts to move it causes intense pain.

Fig. 2. This diagram indicates the laceration of the ligaments and points of fracture in the bones which take place in a Pott's fracture.

The injury is, therefore, followed by considerable shock, and the patient will need some systemic treatment if seen in time.

TREATMENT.

Unless the physician is prepared to make a permanent dressing I think first aid should consist merely in fixing the foot, by splints or cushions, in the position in which it is found. The patient should be transported to a hospital or to his home immediately, if possible, and he should receive the attention of the surgeon at once. It must be remembered that the injury causes intense pain and that the lower end of the tibia is usually pressing so forcibly against the skin that the blood current may be cut off and the skin and subcutaneous connective tissue may be devitalized, if the pressure is not relieved very soon.

When it is possible to use it, a general anesthetic should be employed, ether preferably, as gas-oxygen does not relax the muscles as thoroughly. Complete relaxation of the muscles is necessary for easy reduction of the injury. It is hardly proper, however, to use the word "easy" in connection with proper reduction of this fracture-dislocation. It is rarely, if ever, easy. Complete restitution of the bones to their proper places is almost impossible without a general anesthetic.

The splints or apparatus for retaining the foot in place should be at hand and ready for application before the anesthetic is administered. Rigid splints of boards or metal are rarely applicable in these cases. No one has ever suggested or invented a set of splints or a device applicable to every case of Pott's fracture. One must not apply the reduced injury to the splint but the splint to the individual injury. Therefore, I have for years preferred to make my own retaining apparatus for this fracture-dislocation. I use, and would recommend, plaster of Paris with strips of flexible wood worked in so as to meet the requirements of each case. After it has been molded as one desires, the plaster splint may be split, if necessary, in order to employ massage and passive movements, whenever it is indicated.

In the effort to restore the bones and fragments to their proper places, a picture of the condition must be kept in mind. The lower articular tibial end will be partially dislocated forwards and inwards, the tip of the internal malleolus may be broken off, the internal lateral ligament will certainly be lacerated and shreds of this ligament will be clinging about the end of the tibia, the tibial end may be thrust entirely through it. The astragalus will be dislocated outwards and tilted slightly backward from its proper axis. The tibio-fibular ligament will be torn asunder, the external malleolus will be in juxtaposition with the side of the astragalus, and the external lateral ligament may not be torn asunder, but the fibula will have an oblique fracture about 2½ to 3 inches above the tip of the external malleolus. The superior end of the distal fragment will be tilted inwards against the shaft of the tibia and the lower end of the proximal fragment be separated some distance from the distal fragment. There will be much extravasation of blood and serum. The foot will be everted and abducted and in some cases foreshortened by the lower end of the tibia having slipped rather far forward.

Reduction: As stated before, the patient should be completely relaxed by general anesthesia, if his physical condition will allow.

The leg should be flexed on the thigh to relax the gastrocnemius muscle and an assistant should hold the extremity firmly in this position. The operator should stand facing the patient's supine body, then he should grasp firmly the patient's foot, one hand the heel, the other, the anterior metatarsal region. He should first make strong traction of the foot in the axis of its displacement. Gradually, while drawing firmly on the foot, he should turn it forwards and inwards and carry the movement until the foot is slightly inverted and adducted. If it is possible to do this, reduction will be accomplished. After bringing the foot to the position indicated, let it return to its proper, normal position, and flex and extend the foot at the ankle joint a number of times to ascertain whether motion at the joint is free and shows no grating or marked impediment in the movement. If there is much difficulty in flexion and extension, reduction has not been accomplished and another attempt must be made.

Fig. 3. This diagram shows roughly the usual laceration of ligaments dislocations and displacement of bones which result from a Pott's fracture.

Several things may prevent proper reduction: 1. The fragment of the tip of the internal malleolus may be caught between the articular surfaces of the ankle-joint. 2. If the fragment is broken away from the external rim of the articular end of the tibia, this may slip in between the articular surfaces. 3. The lacerated external lateral ligament may cling to the rough edges of the fractured internal malleolus, and be drawn between the articular surfaces. 4. The lower end of the tibia may be caught between the tendons which are located back of the internal malleolus. By trying repeatedly and carefully, one may usually overcome the impediment offered by all but the last difficulty. Without an open operation, it is almost impossible without doing serious damage to the tendons, bloodvessels and nerves to disengage the bone when the end of the tibia is between the posterior malleolar tendons; I have tried it and I know.

Another good indication of proper reduction is to find the fibula fragments in good alignment. If the dislocation is properly reduced, as a rule the upper end of the distal fragment of the fibula, which had fallen inwards against the tibia, will have been brought outwards when the astragalus has been returned to its proper relative position because, as was stated before, the external malleolus usually holds firmly to the astragalus, so bringing the internal border of the astragalus back towards the internal malleolus by leverage restores the upper end of the distal fragment of the fibula to its proper place.

Dressings. Splints: When good anatomical reduction has been accomplished simple fixation of the foot is all that is necessary. There is no inclination to another distortion, except extension of the foot by contraction of the gastrocnemius and soleus muscles—so the foot must be fixed in order to prevent this. Unless one does succeed in reducing the dislocation, no apparatus will suffice to restore proper alignment and proper function. Practically, the whole problem consists in how to obtain a thorough reduction of the dislocation. No splint, apparatus, or position will do this, if it cannot be done by manipulation while the patient is under the anesthetic.

Dupuytren, Pott and a host of other surgeons have designed and suggested splints for this fracture. I would as a rule, prefer to use a molded splint of plaster of Paris, or silicate of sodium, with strips of flexible wood, to assist in making proper pressure and render the splint less bulky and heavy.

It will be best, perhaps, to put the foot up in a slightly inverted and slightly adducted position, for the first week, then remove the dressing, massage the foot and ankle-joint and lower leg, and reapply a molded splint with the foot in its normal position. This splint may be split after it hardens and be removed in another week for massage and passive movements of the ankle joint, and be reapplied; to be removed every other day for movemnts and massage. Active movements begun just as soon as the tip of the malleolus is sufficiently stable not to be displaced, followed by massage, will do much toward restitution of function. While it is desirable to have the ends of the fibula fragments in good apposition, this is not absolutely necessary. Even if the union of these fragments is by fibrous tissue only, the function of the leg will be good. Therefore, it is not necessary to peril the joint by putting the foot into disagreeable and unnatural position, in order to bring the fibula fragments into anatomical position. The serious matter is, that if the ends of the fibula fragments are not brought somewhere near to apposition, considerable callus will result and later a fixation to the side of the tibia. This may result in irritation of the peroneal nerve and considerable neuralgia or neuritic pain. Besides, this will reduce the flexibility of the ankle and leg.

COMPOUND FRACTURES.

As was stated before, a Pott's fracture may readily become a compound fracture, when the skin is torn, and especially, when all or a part of the lower extremity of the tibia projects through the skin the most careful dèbridement should be done, both of all the soft tissues involved, and of the end of the malleolus (not the articular surfaces). The reduction should be made as in the case of a simple fracture-dislocation.

As a rule, a compound fracture is easier to reduce, because one may sèe what prevents the tibia returning to its place, and remove the obstruction by instrumental assistance. Great care should be employed not to injure the articular surfaces of the astragalus and tibia. Only a small drain of rubber tissue should be introduced through the most dependent portion of the wound as far as the torn ligament, but not within the synovial sac. The wound may be sutured, if necessary, then a thick dressing of sterile absorbent gauze should be applied and a plaster of Paris, or silicate of sodium splint over this. If no fever, nor much pain results, this dressing may remain on for two weeks. After this the treatment should be the same as for the simple fracture-dislocation.

PROGNOSIS: One should always be very cautious in his prediction of the result in a case of Pott's fracture. The result in the majority of cases, is, as regards usefulness, good, but it is rare to have a per-

fect restitution of function. The foot has four movements, as all condyloid joints have. Flexion and extension will, as a rule, be restored, but adduction and abduction will rarely be fully reacquired, and the ankle-joint will for a long time be thicker than the other one.

In rheumatic and gouty subjects this injury will likely be followed by periods of considerable pain, intermittent and exacerbating pains.

EARLY AND COMPLETE IMMOBILIZATION AS A FACTOR IN THE PRESERVATION OF JOINT FUNCTION IN THE TREATMENT OF FRACTURES.

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Nonunion, malunion and loss of joint function as results of fractures are still far too common. The figures of the Surgeon General's report as to the results of the draft, show that an astonishing number of men were barred from service because of bad results following fractures. There were more than 22,000 in all. If this percentage holds for the population of the entire country, the disability figures for poor results after fractures must be very high indeed. In very large part, disability following fractures is due to stiffness of adjacent joints.

I recently had an interesting and unusual opportunity to study methods and results in the treatment of fractures. In our service at the Savenay Hospital Center we received some thousands of wounded Americans from other hospitals in the American Expeditionary Force. These were approved for evacuation to the United States; splinted or operated upon as indicated by the condition in which they arrived. Each patient was checked upon arrival as to his condition. As far as possible, the patients disposition was decided upon at once and operation was performed, position changed, splint put on or he was listed for evacuation to the United States the same day.

Previous to this time, I had also had an experience of more than a year with the British, most of the time, at a Base Hospital in Wales. Here, as well as at London, Bristol, Edinburgh, Belfast and Liverpool, many patients were seen who had reached a much later stage in the evolution of similar injuries. Conclusions from these observations were so inevitable that one feels like expressing rather strongly his views as to what the conditions in civilian practice must be and what general rules must be observed with reference to the treatment of similar conditions.

Medical officers in the military service were regular and civilian. The regular officers were trained for and chiefly concerned with the military campaign proper and the proper conduct of the hospitals. I may say here, however, that having been directly associated with about twenty regular medical officers who were in command of hospitals or hospital centers, I found them always anxious and willing to do whatever was necessary and possible, for our American wounded. I am anxious to say this because I have seen and heard comments to the effect that points of discipline were sometimes placed before the welfare of the wounded men. I never found this to be the case.

Civilian medical officers were, as might have been expected, chiefly concerned with the strictly professional side of the work. However, a handicap that always existed on the part of the civilian officers, was their disposition to do things with professional or personal considerations uppermost, rather than in the military way. I am not competent to speak of the effect of this upon the military campaign. I may say, however, that the treatment of fractures improved directly in proportion to the degree in which we succeeded in getting the surgical staff to comply with the rules set down by the Chief Surgeon, and the consultants in surgery and orthopedic surgery for the care and especially the surgical treatment and splinting of patients.

We had at all times in France considerable difficulty in securing the essentials of treatment for fractures, namely, traction and immobilization. Every trainload of wounded that came to Savenay, brought from ten to forty per cent. of patients with fractures, simple or compound, joint injuries, divided peripheral nerves and muscle and tendon injuries with developing or developed deformity, without any splints whatever. The average, for several months, of such patients without splints, was twenty-five per cent.

There were two factors chiefly responsible for the fact that so many patients were splinted poorly or not at all: First, opposition to splinting by chiefs of services and ward surgeons, who were afraid of producing stiff joints. Second, failure to splint by those who did not appreciate its importance.

In certain areas, to be sure, there was an amount of rush and lack of provision for splinting, which served to excuse the conditions found to some extent. In general, however, the two factors above referred to were chiefly responsible.

The fact that these two same factors are constantly met in civilian practice, impels the writer of this

paper to lay the issue squarely before the medical profession. Stiff joints have been used a bugaboo and an argument against splinting long enough. The fact of the matter is, that stiffness after fractures is quite a different thing than is commonly supposed.

Actual bony ankylosis of a joint occurs with the destruction of the articular surface and formation of bone between the adjacent bony structures; this occurs in fractures only very rarely. On the other hand, severe stiffness is usually found in those cases in which there has been a long period of poor splinting without real immobilization and where there has been continued irritation, mechanical or infectious, or both. It is a very common thing for the tendons to practically unite with tendon sheaths, adjacent fascia and muscle sheaths.

In such cases, there is usually no bony ankylosis whatever. These conditions occur almost never as a result of immobilization. They do occur regularly with poor splinting, with continued irritation from motion and inflammation. That splinting and real fixation may be quite different things can be noticed in almost any general hospital. In other words, stiffness in joints after fractures is more often due to failure to immobilize than to prolonged fixation. Stiffness charged to splinting is practically always due to pathological changes in the soft tissues. In these tissues as well as in many ankylosed joints, stiffness would never have occurred if, by adequate fixation, the parts had been protected from the first against motion and consequent damage and more severe pathological change.

There are a few points that must be emphasized in this connection:

1. The usual splint applied to fractures does not immobilize at all. This applies even to the usual plaster of Paris cast.

2. A considerable number of splints applied to fractures that are followed by joint stiffness, have been put on too tight. This fault is as serious as having splints too loose. Even splints that are bandaged too tightly may not immobilize. Continued congestion of the extremities due to overtightness of a bandage may cause serious stiffness in the ligaments, fasciae, tendons and muscles without any bony changes, whatever.

3. Uniformity in results after fractures was obtained in France during the military activity more nearly by a standard method of splinting and bandaging, than has ever been accomplished in civilian practice.

4. In fractures of the femur, the general adoption of the Thomas splint, which gives traction and immobilization (if properly applied) either from the skin or from the bones themselves, without constriction, will contribute greatly, not only to better results in the alignment of the fragments, but also to a very great reduction in the amount of joint stiffness and disability after such injuries.

5. In other fractures, especially of the forearm, leg and spine, the more general use of plaster of Paris, applied so as to give real immobilization, will reduce the amount of pathological change, secure more rapid healing of the injured parts and give more and better function in adjacent joints than can be obtained in any other way.

THE PATHOLOGY AND TREATMENT OF CHRONIC BRAIN INJURIES, WITH AND WITHOUT A FRACTURE OF THE SKULL.

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Interest in conditions of brain injury has been greatly stimulated during the past few years, this being due, to a large extent, to the frequency of gunshot and shrapnel cranial injuries in the recent war. In these direct brain injuries involving a more or less extensive destruction and loss of cerebral tissue, the gross pathology has been rather an obvious one—a penetrating wound of the vault with varying degrees of local bony change and, most important, the opening of the underlying dura with direct cerebral or cerebellar destruction; the associated subdural and intracerebral hemorrhage together with the cerebral edema was the usual cause of the increasing intracranial pressure sufficient to extrude cerebral tissue. The treatment of these acute conditions cannot be described in this paper and I shall limit my observations to those conditions of chronic brain injuries of civil life rather than of war—that is, of brain injuries associated and unassociated with fracture of the skull, and especially the so-called "fracture of the base of the skull"; brain injuries resulting from depressed fractures of the vault will only be mentioned.

The term "chronic brain injury" naturally presupposes a recovery of life from the acute condition —whether the treatment may have been the expectant palliative or the operative. In a rather large series of these patients, it has become my opinion that the operative treatment is indicated only in about one-third of the cases—only in those where the increased intracranial pressure due to hemorrhage or cerebral edema is of such a height that the recovery

of life and of future normality is more probable by the operative than by means of the expectant palliative method of treatment alone; in the other two-thirds of these patients in whom the increased intracranial pressure is not marked, the assistance of the expectant, palliative method of treatment to the natural means of absorption of the intracranial hemorrhage and of the excess cerebrospinal fluid will usually prove sufficent—not only for the preservation of life but also the recovery of apparent normality. The expectant, palliative treatment of these selected patients is frequently aided by profuse bleeding and discharge of cerebrospinal fluid from the ears or from the nose, extrusion of blood and cerebrospinal fluid through a fracture of the vault into the tissues of the scalp to form hematomata of varying size and, in selected patients, by the repeated lumbar punctures of spinal drainage, so that the intracranial pressure is not permitted to rise to a height necessitating the cranial operation of decompression and drainage. Naturally all depressed fractures of the vault should be either elevated or removed—whether an increased intracranial pressure is present or not—for fear of future complications of mentality, of the emotional reactions and of epilepsy; if in these depressed fractures, however, there is great increase of the intracranial pressure, as registered by the ophthalmoscope and especially by the spinal mercurial manometer at lumbar puncture, then the operation of elevation or removal of the depressed area of the vault should be preceded by an ipsolateral subtemporal decompression to lower this increased intracranial pressure, so that the local operation of elevating or removing the depressed bone can be safely performed and without damage to the adjacent and highly developed cerebral cortex, which otherwise might be extruded and therefore prove a rather dangerous means of decompression. In many of these latter cases, the chances of the patient would be better without any operation than with this method of local operation alone.

Just a word regarding the two stages in these acute conditions of brain injury when *no* operation should be performed—no matter how badly the skull is fractured nor how large the intracranial hemorrhage may be nor how imminent death seems: first, the stage of severe initial shock, and second, the stage of medullary edema—the terminal period. If a patient is in a condition of severe shock following the cranial injury so that the temperature is subnormal and the pulse-rate is 110 and even higher, in addition to the other signs of shock and particularly that of lowered blood pressure, then the treatment should be limited entirely to the treatment of the condition of shock; any operation in this period would merely be an added shock for the patient to overcome, and if he should survive, then recovery is not due to, but rather *in spite of*, the operation. If the patient is unable to survive the shock of the injury itself, surely the additional shock of an operation will not aid him. For this same reason, prolonged neurological examinations of the reflexes, fundi, etc. should be postponed and all the efforts directed toward assisting the patient to survive the shock. When this is accomplished, then the most careful examinations are permissible and the appropriate local treatment possible—and the patient's chance of recovery is not lessened and even prevented. It is the general condition of the patient in this stage of severe shock that demands immediate treatment rather than the local condition, and an important factor in the high mortality of brain injuries has been the neglect in treating this general condition of severe initial shock.

The other important factor in the high mortality of brain injuries has been the frequent delay and postponement of a cranial operation until the natural resistance of the patient to a high intracranial pressure of hemorrhage or of excess cerebrospinal fluid has been exhausted during a period of hours (in those patients having an extreme intracranial pressure and particularly when due to subtentorial hemorrhage) or of days and even of two or three weeks (in those patients having an increased intracranial pressure of less severity and yet being unable to "take care of" it sufficiently by the natural means of absorption). If the patient has continued in the stage of medullary compression for a period of hours and even of days—as indicated clinically by the blood pressure being definitely increased above normal and by the pulse- and respiration-rates being irregular and retarded to even below 50 and, 10 respectively,—and then the pulse- and respiration-rates begin to rise rapidly, the blood pressure to fall and the temperature to ascend (the typical picture of medullary edema and the *terminal* stage), to advise at this late period any cranial operation "in the hope of giving the patient a chance", cannot be too strongly condemned as these patients all die with or without operation—in fact, any operation performed in this stage of medullary edema merely hastens the exitus. This period of medullary edema can usually be anticipated and even prevented in the treatment of brain injuries, either by the expectant, palliative method or by the operative method of cranial decompression and drainage when the clinical signs—and especially those revealed by the ophthalmoscope and by the spinal mercurial manometer—indicate a

marked increase of the intracranial pressure to such a height that it is doubtful if the expectant palliative treatment alone can lower it. To permit a patient to enter and to continue in the stage of medullary compression is running a very great risk—either of death or of permanent mental and physical impairment. But if the patient has advanced from the stage of medullary compression into that of medullary edema with an increasing pulse- and respiration-rate, no operation is advisable—the patient is not benefited, to say the least, and cranial surgery is merely discredited.

In a recent work upon the diagnosis and treatment of brain injuries* I realize now that I did not emphasize sufficiently the relative unimportance (in my opinion) of a definite increase of the blood pressure except as indicating the lateness of the time for operative interference, since this increase of the blood pressure is a sign of medullary compression and the patient should be given an opportunity to recover by an earlier lowering of the increased intracranial pressure, either by the expectant, palliative or by the operative method. If we wait in the treatment until the blood pressure is definitely increased above normal, then we are letting the patient reach a very serious condition of medullary compression and it is then frequently too late to aid him even by an operation of decompression and drainage. In my opinion, the ophthalmoscopic and spinal mercurial manometric findings are much more valuable as definite and delicate tests in ascertaining early the intracranial condition of an increase of the intracranial pressure, whether due to hemorrhage or to an excess cerebrospinal fluid. Naturally, the presence of shock is characterized by a lowered blood pressure together with a subnormal temperature and an increased pulse-rate, whereas the stage of medullary edema presents a rising temperature, pulse- and respiration-rate and also a falling blood pressure, so that clinically these two periods may at times be confused.

During the past few years, the profession has been more and more impressed with the end-results in these patients; to be sure, the preservation of life is essential and yet the treatment of the acute condition should not be only to preserve life, but also to restore a condition of approximate normality, both mentally and physically. The attitude of the profession has largely been one of surprise if a patient with a "fracture of the skull" and particularly of the base, recovered; and if the mental, emotional or physical condition was not so normal as before the injury, "well, he had a fracture of the skull and should consider himself fortunate to be alive". It has been this feeling of comparative helplessness that has permitted these patients to be very much neglected—it being considered that the mental and physical impairment was due to a definite gross primary brain lesion at the time of the injury and therefore, an irreparable condition. Fortunately, however, this is a fact in only a small percentage of the patients having had a severe cranial injury with or without a fracture of the skull, and these are the selected patients having the so-called "chronic brain injuries", that I wish to discuss here.

During the past eight years, I have had the opportunity to examine and to treat a large series of patients having acute brain injuries, and it has been very impressive to note, either at autopsy or at operation, the comparative rarity of extensive cerebral laceration in these patients. It is conceded that in large compound, depressed fractures of the vault and in the occasional gun-shot injuries in civil life, extensive cerebral laceration does occur and, therefore, if the patient should survive, an irreparable brain injury presents its symptoms and signs. Yet it is indeed most infrequent for gross tears in the cerebral cortex to occur in the usual cranial injuries with or without a fracture of the vault or of the base of the skull. At autopsy upon those patients who have died from the extreme initial shock of from an infective meningoencephalitis or from a terminal medullary edema resulting from high intracranial pressure of hemorrhage and of excess cerebrospinal fluid, the most common of cerebral lesions was a contusions of the superficial layers of the cortex of the anterior and inferior surfaces of either frontal lobe and of the tip of either temporo-sphenoidal lobe, but no extensive laceration—merely a bruising of these areas covered by a thin layer of localized supracortical hemorrhage. Even these findings, however, were not frequent. The most common post-mortem condition was a large amount of free bloody cerebrospinal fluid associated with a layer of supracortial hemorrhagic clot of varying thickness, the brain itself being swollen and edematous, of the so-called "wet" and "water-logged" type. This condition of supracortical hemorrhage and excess cerebrospinal fluid is also the usual operative finding and rarely is a gross cerebral laceration exposed. The relative infrequency of large cerebral lacerations is also demonstrated clinically in those patients who make such excellent recovery of function e. g., from

*"The Diagnosis and Treatment of Brain Injuries, with and without a Fracture of the Skull," J. B. Lippincott Co., Phila., 1921.

hemiplegia, following most severe cranial traumata with and without an operative decompression. thus confirming the opinion that the immediate paralysis was due rather to local compression of hemorrhage and of cerebral edema than to a gross cerebral laceration. It is in those patients having a high intracranial pressure, especially when it is due chiefly to hemorrhage, that the subtemporal decompression and drainage is the treatment of choice, from the standpoints not only of recovery of life but also of the ultimate recovery of function.

We are concerned in this paper with those patients who have recovered from the immediate effects of the acute cranial injury and yet remain with symptoms and signs of definite impairment—severe persistent headaches, early fatigue, inability to work throughout the day as formerly, dizzy spells, a definite change of personality of the depressed or of the excitable and irritable type, and even epilepsy in its various manifestations. These are cases that form a most interesting group for study.

It is an opinion rather common among the laity and to a less extent in the medical profession, that once an individual has had a "fracture of the skull," he is never the same again—if not mentally and physically, then at least in the emotional reactions; that he is more irritable, with periods of depression or of excitement, frequently complains of persistent headache, has a sense of early fatigue so that the former day's work is impossible or at least difficult, occasional spells of vertigo and at times even epileptiform seizures. Definite changes of the personality have been very frequently observed, as manifested by less interest in surroundings and ambitions for the future, and unreliability to such a degree that he is termed a "loafer" and a "good-for-nothing". The condition of a large percentage of those patients was called that of "post-traumatic neurosis"—a functional disturbance resulting from the "shock" of the injury, "concussion" of the brain, etc., while the condition of the smaller number of these impaired patients was consideerd as being due to a gross organic injury of the brain at the time of the accident, such as cerebral contusion and lacerations associated with hemorrhage of varying degree. In the absence of macroscopic lesions to be observed with the naked eye, then the condition was held to be due to minute and possibly microscopic changes not only in the cortical nerve cells themselves, but also in their interrelationship and associated nerve tracts, and thus an irreparable condition.

With this post-traumatic condition in mind, in 1912 I attempted to ascertain the present status of those patients at three of the large hospitals in New York City who had had a "fracture of the skull" during the preceding decade of 1900-1910. (The mortality of the acute condition was 46 to 64 per cent. while the operative mortality itself was 87 per cent. This latter was due chiefly to the type of operation performed, usually an extensive osteoplastic "flap" exposure, and the frequent performance of the operation during the initial stage of extreme shock or the terminal stage of medullary edema. Under these conditions, Doctor Pearce Bailey was undoubtedly correct in the belief that these patients "get along just as well without as with operation"). Of the total patients who were discharged from those three hospitals as "well", "cured" or "improved", I was successful in locating only 34 per cent., but of this number 67 per cent. were still suffering from the effects of the former injury—the chief complaints being headache, early fatigue, change of personality and, in a very small number, convulsive seizures. The records of these impaired patients were very instructive in that their hospital residence was usually longer than that of the other cranial injury cases by a number of days and even of weeks; while frequent notes were found of prolonged stupor and even of unconsciousness, of severe headache and of retarded pulse-rate—symptoms and signs indicative of an increased intracranial pressure; rarely was an opthalmoscopic examination made and even more rarely had a lumbar puncture been performed. In examining these chronic cases, I was very much surprised to find in a large number of them the definite evidence of an increase of intracranial pressure, as observed with the ophthalmoscope and particularly with the estimation of the pressure of the cerebrospinal fluid at lumbar puncture. Upon nine of these selected patients, the operation of subtemporal decompression and drainage was performed even at this late date following the injury and the operative findings were all similar—no gross cortical lesions exposed, but a "wet", swollen, edematous brain under varying degrees of increased pressure; along the supracortical veins in the sulci, however, was a cloudy induration of new tissue formation surrounding the vessel walls, which were also thickened. Microscopical sections have now been made of this condition occurring in similar patients and also in children who had a supracortical hemorrhage at the time of birth; and this tissue formation is now recognized as the organization "residue" of connective tissue of a former layer of supracortical blood which had collected chiefly in the sulci about these veins and thus had blocked the little stomata of exit of the

cerebrospinal fluid through the walls of these vessels —the main channels of excretion of the cerebrospinal fluid into the blood streams. In this manner, a mild condition of external hydrocephalus had been produced by this partial blockage of the excretion of the cerebrospinal fluid.

Microscopic sections of the cortical cells and their normal arrangement have only rarely disclosed a definite change of structure, although this added complication cannot be excluded in any case. It is the pathologic condition, however, about the supracortical veins that has been overlooked in the past; and it has only been since we learned that over 80 per cent. of the excretion of the cerebrospinal fluid occurs through the supracortical veins lying in the sulci, that it was recognized that this condition of new tissue formation following the hemorrhage was the main lesion in causing the edematous brain *of the cerebrospinal,* with varying degrees of intracranial pressure. Those patients making excellent recoveries with the expectant, palliative treatment alone—and over 50 per cent. do, undoubtedly are the ones in whom the natural means of absorption have been sufficient to "take care of" the free supracortical blood, so that no real residue or new tissue formation results, since practically all of the hemorrhage has been absorbed. I have had the opportunity to demonstrate the confirmation of this opinion in three patients who had had cranial injuries with a resulting intracranial hemorrhage, as indicated by the bloody cerebrospinal fluid at lumbar puncture not sufficient, however, to produce a marked increase of the intracranial pressure, so that the expectant, palliative method of treatment alone was indicated and sufficent to obtain an excellent recovery. Later, upon death from other causes, autopsy in these three cases* disclosed little, if any, new tissue formation about the supracortical veins in the sulci; the hemorrhage having been entirely absorbed, the brain was not edematous, there being no blockage of the excretion of the cerebrospinal fluid.

*During the past seven years I have insisted, before performing an operation upon any patient having a chronic neurological condition, that the nearest relatives give me, in writing, permission to make a post-mortem examination in case the patient should die,—and naturally one does not expect the patient to die—in order to ascertain the real cause of death, rather than accept the common report of "cerebral or pulmonary embolus" and "thrombus formation". If death is due to an operative error or to some avoidable complication, then it is for the surgeon to realize it so that its repetition can, if possible, be prevented in the future patients. Moreover, the accuracy of the diagnosis is this confirmed or disproven and the pathological lesion is carefully examined. The co-operation of the nearest relative in permitting these examinations has been the rule; in only two cases in a series of over 1,000 operated patients was a flat refusal maintained—and no operation was performed.

Those patients who have had an intracranial injury, and most probably a supracortical hemorrhage, (with or without a fracture of the skull), who have not recovered their former normality, and in whom headache, early fatigue, change of personality or even convulsive seizures persist, should be most carefully examined from the standpoint of the presence or absence of an increased intracranial pressure as found in the fundi with the ophthalmoscope and more accurately still by the spinal mercurial manometer at lumbar puncture. If no increase of the intracranial pressure is present, then the treatment can be only of the expectant palliative type for the intracranial damage has already occurred, whether due to a primary gross or minute microscopic lesion of the cortical cells or to a prolonged high intracranial pressure which has gradually become lower as a result of the atrophy of the cerebral cells, a permanent impairment—a compensatory lowering of intracranial pressure at the expense of the brain itself. But if a definite increase of the intracranial pressure persists in spite of the usual expectant, palliative treatment, then the patient can be greatly benefited and improved by means of an early subtemporal decompression and permanent drainage of the blocked cerebrospinal fluid. The dura should naturally be opened widely and permitted to remain open and not resutured, otherwise the decompression is of only temporary value. Excellent results have been obtained in this class of patients and the earlier the condition of increased intracranial pressure can be lowered to normal, just so much more of an improvement can be expected from the operation.

In closing, let me merely mention the similar chronic condition occurring in children as the result of an intracranial hemorrhage at the time of birth—usually a difficult labor, with or without instruments. They are usually first children, and unless convulsive twitchings occur within several days after birth, or the child is unusually excitable or stuporous, the condition is commonly overlooked and the baby may be considered a normal child until the seventh or eighth month, and even later. Then it is observed that the child is not holding up its head, and later does not sit up or attempt to stand until months after the normal time; convulsive twitchings may or may not be present; speech is usually retarded—in fact, the entire physical and mental activities are delayed and retarded in varying degree. If examinations now show a marked increase of the intracranial pressure, these are the selected patients who can be greatly benefitted by subtemporal decompression and permanent drainage of the blocked cerebrospinal

fluid, even at the late date of several years following the injury—just as in the chronic brain injuries occurring in adults. However, the ideal treatment of these conditions of intracranial hemorrhage is at the time of the acute condition,—within the first few days following birth in the baby, and within a period of hours following the injury in adults. In these new-born, if repeated lumbar punctures with removal of large amounts of bloody cerebrospinal fluid, do not suffice to lower the increased intracranial pressure, then a modified subtemporal decompression and drainage operation is immediately indicated, just as in the acute brain injuries of adults having the symptoms and signs of high intracranial pressure. Infants who survive a birth hemorrhage, whose increased intracranial pressure has not been lowered to normal, cannot develop as they should, either mentally or physically. As a result of this condition there is produced that large group of spastic and defective children—the bane of the pediatrist, orthopedist and neurologist. After a lapse of years, however, the selected children having an increased intracranial pressure can be only improved by operative lowering of the pressure. I have now operated upon 419 of these children, out of almost 4000 cases examined, of ages varying from five hours to 23 years; and I may state that the lesion is practically the same as occurs in adults from cranial injuries with a supracortical hemorrhage. The persistent increase of intracranial pressure is due to the partial blockage of the excretion of the cerebrospinal fluid by the new tissue formation resulting from the supracortical hemorrhage about the veins in the sulci, producing the characteristic "wet", edematous condition of the brain.

In conclusion, it is only in those patients having a definite increase of the intracranial pressure that any improvement can be afforded by means of the cranial decompression. Naturally, if minute changes have taken place in the cortical cells themselves, then an irreparable damage has occurred and even if the increased intracranial pressure is lowered to normal by operation, these patients cannot make a complete recovery of function, although the relief of the pressure should improve their condition. It is, however, in those patients in whom the increased pressure resulting from a partial blockage of the excretion of the cerebrospinal fluid is the main pathological condition and especially in those who have no organic cellular changes—that the operation of subtemporal decompression and permanent drainage affords the greatest ultimate improvement and, in the more fortunate ones, even an apparent cure.

20 WEST 50TH STREET.

THE CHIEF LESIONS FOLLOWING SPINAL FRACTURE.

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Fracture of the spinal column with damage to the cord or roots is considered, and rightly so, a most serious injury. Though the spinal cord is the best protected structure of the body, once the bony canal is shattered the cord is most susceptible to injury, and its extremely low, or perhaps absent regenerative powers, makes is unique among the body structures. The integrity of the protecting bony canal once broken, it becomes a menace by reason of fragments driven into the cord, and the inelasticity of the meninges prevents the escape of inflammatory exudates, with resulting compression of the nerve fibers.

And even though the cord may have escaped noticeable injury at the time of the fracture, later, from new bone growth about the seat of the fracture, or to fibrous or scar tissue formation with adhesions both without and within the meninges, cord functioning may be seriously impaired. Conditions of spinal farctures with later disability, due to changes in the fractured vertebrae or to late cord impairment, are much less common than fracture with immediate cord involvement, but they do occur rather frequently. The signs of late cord or bone involvement are often extremely difficult to diagnose correctly, for the symptoms of the original fracture may have been slight, or the fracture may have been overlooked entirely. This is apt to happen if other parts of the body are also injured. Or the signs of cord impairment may closely simulate the sign of a chronic organic cord disease, as myelitis or multiple sclerosis. Or true organic cord disease may follow a spinal fracture in which the cord has apparently escaped damage.

A few years ago I operated upon a man of 28, who had received a severe injury to the spine in a fall 12 years previously. As there was no apparent injury of cord or bone, no roentgenogram was made, and the condition was diagnosed as a "severe sprain of the back". Three years later he developed the signs of multiple sclerosis—pasticity of legs, absent abdominal reflexes, and pallor of the optic discs. The condition slowly progressed during the following years, so that when I saw him he was markedly disabled, getting about on crutches. The symptoms were undoubtedly those of multiple sclerosis, but because of the history of an injury to the spine a roentgenogram was made. This showed marked deformation and thickening of the laminae of the eleventh and twelfth dorsal vertebrae. Laminectomy disclosed

the affected laminae more deformed and thickened than was apparent in the skiagraph. There was a marked kyphosis of the cord at this point, and the reason for this was found to be either a dislocation backward of the eleventh dorsal vertebra, or extensive callus formation of the posterior surface of the vertebral body. Beyond some lessening of the spasticity in the legs, no improvement followed the operation.

It has been my experience that spinal evidence shown in roentgenograms falls short of the condition found at operation. The spine, especially in the thoracic and upper lumbar region is a difficult part to radiograph, and because of the arrangement of the bones roentgenograms of the spine are difficult to read. This difficulty can be overcome in part by making several views of the suspected part of the spine at different angles.

Many patients are seen with old fractures showing cord lesions upon whom for various reasons no operation was done, or if done, it was not very successful. In some of these patients upon whom an operation was done with little or no improvement, careful examination will show that the lesion was not correctly localized, and that the laminectomy had been placed some distance from the site of the trauma. Naturally, it is of paramount importance that the site of the trauma to the cord be positively identified before proceeding to operate. While in the majority of cord traumas localization is not difficult, especially with the aid of the *x*-ray, yet occasionally in young children, if there is little or no bone deformity, it may be very difficult to decide the exact location of the lesion. Unless the surgeon has determined to his own satisfaction the site of the injury, it is better to defer operation until he can be certain, and not subject the patient to a possibly useless laminectomy.

Some years ago I operated upon a child of seven years, who eight months previously had fallen from a height, causing paralysis of legs and sphincters. The *x*-ray picture showed no deformity of the spine, and a laminectomy three days after the injury, at the level of the sixth and seventh dorsal vertebrae revealed no lesion of thc cord.

When seen by me eight months later the degree of paralysis of legs and sphincters was the same as described at the first operation. Another roentgenogram showed an apparently normal spinal column. Repeated careful examinations located the lesion at the third dorsal vretebra. Laminectomy at this point revealed many adhesions between the cord and meninges, the large amount of fluid in the meshes of the adhesions giving them a cystic appearance. The cord was surrounded and compressed by a dense mass of yellow fibrous tissue due to old hemorrhage. But little of the scar tissue could be removed, and but little improvement followed the operation. The first operation, if done at the proper site, would have removed the blood clot and offset the edema, and would doubtless have been of much benefit.

Patients with cord lesions due to old fractures present symptoms varying from atrophy of a muscle group, foot drop, moderate spasticity of one or both extremities, to severe paralyses with impairment or loss of sphincteric control. Some of these patients had shown a gradual though partial return of function after the initial trauma, and operation was withheld because of this improvement. Later on improvement ceased, leaving the patient more or less disabled. In some of the patients retrogression had set in after the initial improvement and they gradually became more disabled. Naturally, restoration of function occurred in those portions of the cord undamaged, or not severely damaged, by the initial injury. But we should not conclude therefore that the cord tracts not regaining function are destroyed. Other factors besides laceration can prevent their functioning. Others of these patients with old fractures, and these usually of the type having mild cord involvement at the time of injury, show a gradually increasing impairment of function. Here the signs point to, and an operation will disclose, either mild compression by bone with resulting inflammatory thickening of the meninges, or organization and contraction of blood clot, or adhesions between pia and arachnoid with collection of fluid, and resulting compression of the cord tract. Or new bone growth (callus formation) may be revealed as the cause of the increasing cord impairment.

These patients are usually regarded as having suffered permanent damage to the portions of the cord showing impairment, and operation is rarely recommended because holding out little or no promise of benefit. But many of these patients can be improved by operation, even at a late date, and in some a brilliant result is secured. These patients should not be abandoned as hopeless cripples merely because a period of several months, or even years, has elapsed since the injury was received. Although it is too much to expect that operation will completely relieve many of these conditions yet definite improvement may follow laminectomy even at a late date.

However, the many reported cases of benefit re-

sulting from late operation, when symptoms of recovery cease or retrogression has set in, only indicate the good that could have been done by early operation, for the factors of continued compression, bone, hemorrhage, edema or scar tissue, that brought improvement to a standstill had certainly worked harm that would have been prevented by an early operation.

In a large proportion of these patients, the *x*-rays will disclose no displacement or thickening of bone, and operation, if undertaken, will confirm the negative *x*-ray findings. And yet in many of these old conditions of fracture, a simple exploratory or decompressive laminectomy, will often give astonishing and brilliant results. Then what was the cause of the disability? The initial injury produced undrained hemorrhage in or about the cord, later scar tissue and adhesions formed about the cord and in the arachnoid and dura, and these lead to the production of sacculations filled with fluid. I have seen patients in whom the arachnoid was adherent at some points with fluid-filled sacculations at other points, giving the appearance of multilocular cysts. This condition, alone, by compression is capable of giving rise to marked signs of cord impairment. When such a condition is encountered the arachnoid should be widely opened, and the adhesions divided to allow the proper flow and return of spinal fluid, and to prevent sac- or cyst-formation. Under no circumstances should the attempt be made to dissect scar tissue from the cord. If this is attempted the condition will almost certainly be aggravated.

There are, however, a large number of spinal fractures in which the cord and its roots escape damage. According to Pearce Bailey, in almost one-third of the cases of fracture of the spine, the cord escapes injury. This estimate in all probability is too low, as a large number of patients with this type of spinal injury are treated in the orthopedic clinics and the majority of them are not reported. In many of these injuries, there is but little alteration of the normal spinal curve. Unless careful examination is made, these conditions are apt to be diagnosed as "sprains or contusions of the back". In others, the amount of bony deformity and angulation is such that it is rather difficult to understand how the cord escaped involvement. In two fractures of this type, reported in a previous article, the vertebral bodies were almost completely crushed, yet these patients were able to stand and move about after the accident. As we know that many of the posterior arches, or laminae, can be removed without materially weakening the spine and since, as we have just said, crushing of a vertebral body does not render one unable to stand erect, it is apparent that the main support or strength of the spinal column lies in the articulations on the transverse processes. Moreover, it is rare in fracture by indirect force to have the cord injured (except by hemorrhage) unless there is rupture of these articulations. The converse is also true, that the most severe injuries of the cord are seen when these articulations are ruptured,—the familiar unilateral or bilateral fracture-dislocation of one or more vertebrae.

In many fractures of the spinal column without cord signs, the fracture has been entirely overlooked. Thus, in the case of a woman, reported in a previous article, who fell on a stairway striking the back on a step, there were no immediate signs of nerve involvement and a fracture was not suspected. Months after the accident and when all pain had long since disappeared, signs of cord impairment appeared and gradually increased. Only when the cord signs became marked was attention directed to the old accident and the *x*-ray picture disclosed much callus formation at the site of the injury, the twelfth dorsal and first lumbar vertebrae.

In the absence of cord signs and evident protrusion, or "knuckle" of the spine, the diagnosis is apt to be "simple sprain" or "contusion". If other injuries are present the spinal fracture without cord involvement is apt to be overlooked. In one such patient, who sustained severe burns of the arms and shoulders, in addition to the injury of the back, the burns were treated as the principal lesion and in the absence of cord signs, no attention was given to the spine, though the patient complained of pain in the lumbar region. Three weeks later, when the burns were nearly healed, the persistence of the pain directed attention to the spine, and examination revealed alteration in the normal spinal curve in the dorso-lumbar region. The *x*-rays disclosed crushing of the body of the twelfth dorsal vertebra. These instances indicate the necessity of careful examination, both clinical and by the *x*-ray, of all cases of suspected injury to the spine. Although in many of these conditions the failure to recognize a spinal fracture does not result seriously, it is readily conceivable that in a patient able to move about in bed, with the fracture not immobilized, sudden twisting or turning movements by the patient or his attendants, may easily convert a fracture without cord signs into a fracture with serious cord involvement. Also failure to recognize a fracture and to restore the normal spinal curve may result in a weakened spinal column and more or less permanent disability with perhaps ap-

pearance later of cord symptoms due to new bone formation. This latter condition is more often seen when the fracture occurs in the laminae of the vertebrae.

The treatment of fracture of the spinal column without cord symptoms is immobilization. In fracture of the cervical vertebrae, immobilization is best secured by a plaster collar so applied as to hold head and neck rigid. If the fracture is high in the cervical region, an extension should be made from the collar about the forehead. If the fracture lies in the lower cervical region, an extension should also include the upper trunk. After from six to ten weeks, when all pain and tenderness have disappeared, the plaster may be followed by a stiff leather collar, which gives support, but is more comfortable and allows greater freedom of movement. If the fracture lies in the laminae of the dorsal or lumbar vertebrae, a moulded splint of plaster on each side of the spinal column, connected by transverse bands above and below the lesion, will be found the most satisfactory way of immobilizing the fracture and preserving the normal outline of the spinal processes. Fracture of a vertebral body, or bodies, if seen soon after the injury, is best treated by hyperextension on a Bradford frame, for the purpose of removing the "knuckle" or angulation and restoring the normal spinal curve. If, as often happens, the fracture has not been discovered until some weeks or months have elapsed, it will be impossible to correct the deformity and the patient, though getting firm union, will have a permanent "knuckle" or angulation and some disability. When the Bradford frame is employed the patient is confined to bed until all pain and tenderness have disappeared, (a matter of some weeks). A series of plaster jackets must then be worn continuously for ten or twelve months. A steel back brace is then substituted for the plaster jacket, and should be worn until twenty to twenty-four months have elapsed since the injury.

If the patient will consent, the period of convalescence can be shortened to about twelve months, by doing one of the several spine fixation operations such as the Hibbs or Albee operations. The advantages of the open operation are that it gives firm union and shortens the period of recovery to about twelve months. Its disadvantages are: danger of sepsis (not great); breaking down or non-union of the graft; and the fact that operation makes permanently rigid a larger portion of the spine than does the plaster jacket method. This last is not very important as permanent fixation of several vertebrae in the dorsal or upper lumbar region will not seriously inconvenience the patient. Of course the plaster jacket should be worn for months after any of the spine-fixation operations. It is my opinion that if the injury has resulted in the partial destruction of only one vertebral body, it is best treated by the plaster jacket method. If, however, one, two or more vertebral bodies have been badly crushed one of the open operations will give firmer union and better functoinal results. Under either method of treatment though the patients may recover with firm union at the point of fracture, few of these patients doing active manual work previous to the injury will return to the same sort of work. Many of them are not able to, especially those in whom the injury was to the lower spine. The long period of convalescence is probably partly responsible and loss of confidence may also be a factor. In all the fractures without cord damage that we have seen in the cervical region, the spine, after twelve to fifteen months, was normally strong and supple, and it is probably the fear of another injury that keeps these patients from their former work.

Recent fractures of the spinal column presenting immediate signs of cord involvement, can be divided, on a pathological basis, into two classes; those showing signs of partial lesion of the cord, and those showing signs of complete cord lesion. But from the clinical standpoint we cannot so divide them. For many fractures showing immediate signs of complete cord lesions are really conditions of partial, at times slight, cord injury. For in addition to the loss of function of the damaged fibers, the shock or jar of the injury may cause an inhibition of function of the sound fibers more or less complete for a variable period of time. Few patients having injuries of this type short of a complete transverse lesion, will be as seriously disabled eventually as they appear to be shortly after the injury. For to the motor paralysis and impairment of sensation due to the laceration of nerve fibers, is added this inhibition of function due to the local shock of the trauma. This will disappear in time, (days or weeks) and if we possessed signs that enabled us to distinguish between laceration of fibers or tracts, and inhibition of function due to concussion, surgical interference would not be so necessary, as operation can do nothing for lacerated cord fibers.

In patients with recent fractures showing signs of partial abolition of function there is partial and irregularly distributed motor paralysis with abolition of some of the reflexes and areas of anesthesia below the site of the injury with probable disturbance of sphincteric control. In these instan-

ces the signs are due either to contusion, laceration or compression of the cord by the crushed vertebrae or to compression by hemorrhage in or around the cord.

Experimental studies of contusion of the cord show, in proportion to the severity of the contusion, disintegration of the axis-cylinders; but this is usually less marked than in conditions of compression. In continued compression, in which the hemorrhage becomes an added element, the nerve fibers disintegrate and finally liquefy. It should be born in mind that, even though there may have been no laceration of cord fibers, even a moderate degree of compression if suddenly applied, as is the case with fracture, will cause more serious and permanent damage to cord fibers than a greater degree of compression gradually applied, as in tumor.

In partial lesions of the cord there are found destroyed, damaged and sound fibers side by side. Of the destroyed fibers nothing is to be expected; they will not regenerate. The fate of the damaged, and of many of the sound fibers, depends on whether the factors producing the injury are temporary or permanent. These factors are compression by bone, blood, and the certain edema which appears after every injury to the cord. If this compression is quickly removed, not only will the sound fibers be preserved, but functional and even anatomical repair will take place in many of the damaged, but not in the destroyed fibers. But if compression due to any or all of the above-mentioned three factors is at all severe, and is allowed to continue for as short a period as four days, not only will secondary degeneration appear in the damaged fibers, but many of the sound fibers will also be involved.

Also in contusion of the cord hemorrhage and edema, at least edema, are always present and if not relieved early by operation will increase the ultimate impairment. F. A. Allen demonstrated the harmful effects of this edema, by the improvement that followed experimental incisions into the cord after spinal fracture in animals.

There are, however, many fractures with milder degree of cord injury, in which there is no immediate loss of function. In this condition shortly following the injury, there are cramps in the legs, burning and tingling of the skin of the legs followed by a progressive loss of power and sensation. The signs indicate not laceration but compression of the cord by bone or hemorrhage. The progressive march of the symptoms shows, not a further narrowing of the bony canal, but an increase of the hemorrhage and arrival of the destructive edema. Here early laminectomy is imperative if we would save the cord, or parts of it, from permanent injury. Even if no large hemorrhage is present, there may be a backward dislocation of the vertebral body, so that the cord is "kinked" and the canal narrowed; even if it is impossible to remove the bone projecting into the canal, the laminectomy gives the cord ample room to curve over it, and allows for the escape of the inflammatory exudate. Even if the signs of cord injury are but slight, if they are progressive, laminectomy should be performed and the dura opened to allow drainage of whatever hemorrhage may be present, and to ward off by this "spinal decompression", the effects of the edema which invariably follows the injury of the cord, and which is so destructive to the delicate fibers. Naturally, where there is no bony displacement, and the signs of cord injury are slight, and improvement begins almost immediately and continues, operation is not advisable.

It is in spinal fracture with signs of immediate complete abolition of function that the opinion of surgeons is most sharply divided as to the advisability of operative interference. Many hold that immediate complete motor and sensory paralysis, with abolition of all reflexes below the lesion and loss of sphincteric control, shows a total transverse lesion of the cord, and laminectomy is unjustifiable and can do no good. This would be true, did the above symptoms positively indicate, as they do in many instances, complete destruction of the cord. But there have been many instances reported in which all of the above signs were present, and which were considered complete lesions of the cord, in which, later, partial function returned even without operation, and many reported in which operation was followed by fair recovery. The Bastian-Bruns so-called law, which is that there is a total loss of tendon reflexes in complete lesion is, as an aid to diagnosis, only of value in the negative sense. That is, the presence of reflexes makes it certain that there is not a total lesion, while the absence of reflexes is not proof that the lesion is total unless such absence is persistent. In many instances of partial lesion, there is a total loss of reflexes for more than eight days. This is due to concussion interrupting nerve conductivity and is a condition from which the fibers recover. There are no signs, short of a deformity at the site of injury so great as to show complete obliteration of the bony canal, which prove a complete transverse lesion of the cord.

It has been regarded by many that complete abolition of function below the injury must indicate, if not laceration, at least most severe compression of

the cord. This is by no means necessarily the case. Alan Newton has shown by experiments in animals that the spinal cord is extremely sensitive to light degrees of compression. He found that a glass rod gently placed on end on the exposed cord arrested conduction immediately. After removal of the compression, conduction returned after an interval varying directly with the duration of the compression, and the amount of interference with fuction remaining after eleven to fourteen days following the experiment depended on the same factor. These results of Newton's experiments are in themselves a strong argument for the early operation, showing the beneficial effect of early removal of pressure due to whatever factor.

Bastian, Kocher and others have outlined signs that indicate complete lesion of the cord, but the instances described above and many others, show that these signs do not prove destruction of the cord, and that we cannot rely upon them. Kocher believes that operation is unjustifiable in case signs of complete lesion are present, and favors operation in partial lesion only when the symptoms have come to a standstill. But, as we have seen, the signs of complete lesion are not absolutely trustworthy, and delay in partial lesions may irreparably damage the cord. A much more rational stand is that taken by Dr. Walton who says: "Early operation will not only accomplish all that later operation will do for these cases, but will do it better".

Treatment. There has been, and still is, a rather marked difference of opinion as to the proper treatment of these injuries. Many neurologists and surgeons contend that in the majority of fractures of the spine with cord involvement, a policy of watchful waiting without operation is the better treatment, until the cord has demonstrated its ability or inability to progress towards normal functioning. On the other hand, some few of us surgeons and neurologists, insist that in the majority of these injuries early laminectomy after the patient has recovered from shock of the trauma, is the more rational treatment, and yields by far the better results.

In the discussions that have gone on in late years the opponents of early operatoin have maintained that laceration of the cord cannot be remedied by operation, and that the nerve fibers, if severely injured, degenerate whether compression is immediately removed or not. That removal of pressure by early operation will not cause the already destroyed fibers to regenerate is true. But the opponents of early operative interference have apparently overlooked several important facts. One is that in fracture with damage to the cord, short of a complete transverse lesion, there are many fibers and tracts that escape injury wholly or in part. And there are other factors that will work harm to the nerve fibers in addition to the damage received at the moment of injury. If operation is not done, compression by bone, hemorrhage, or the quickly following edema, will destroy the already damaged fibers and involve many of the sound ones. Interruption of conductivity of nerve fibers after fracture does not necessarily mean that those fibers are destroyed. In practically every instance of damage to the cord, short of complete lesion, many of the interrupted fibers will later functionate, and it is to preserve the integrity of the sound fibers, and to give the best chance of recovery to the damaged but not destroyed fibers, that early operation is urged. In former years laminectomy was a formidable procedure, and operation was delayed on this account. But at the present time the danger of laminectomy in skilled hands is but slight in comparison with the possible benefits.

Signs of cord injury in fracture are due to the following factors:

1. To fragments of displaced bone causing contusion, or laceration of the nerve fibers, or a narrowing of the canal by the fractured laminae, or projection backward of a vertebral body, causing compression of the cord. In these conditions the signs of cord injury arise immediately after the accident.

2. Hemorrhage, either into the cord substance (hematomyelia) causing laceration of the fibers, or hemorrhage around the cord, either intra- or extradural, causing compression of the cord. In these conditions the signs of cord involvement come on shortly, perhaps hours, after the injury, and are usually progressive.

3. Edema, both within and around the cord, causing compression of the fibers. In considering the compressive effect on the cord of edema, it should be borne in mind that the cord substance is surrounded by a closely fitting envelope, the pia, which sends trabeculae into the substance of the cord, which support and maintain in position the almost jelly-like substance of the cord tracts. The spinal pia is thicker and less elastic than the pia mater of the brain. Unless the fluid can escape, edema arising within the cord after injury will cause compression of cord fibers, and is a serious menace, not only to the damaged fibers but also to sound ones. Edema within the cord itself is much more dangerous to cord integrity than a much larger collection without the cord, that is, in the subarachnoid space. In itself edema gives rise to symptoms that appear like those

due to hemorrhage, some hours after the accident, and these symptoms are progressive. This edema, present after every injury to the cord, and by its compressive effects so destructive to nerve fibers, forms one of the chief reasons for early operation. Its power to harm has been overlooked in the past, and recent operations have shown that in many instances, signs indicating injury or compression by bone are really due to the compressive and destructive effects of the edema.

4. Narrowing of the spinal canal at the site of injury by new bone growth or the formation of scar tissue. In this condition the signs arise months after the injury.

These factors operate singly or in combination. It is only in rare cases and in the slighter injuries that these factors operate singly. In the majority of fractures of the spine, two or more, and at times all of these factors are seen. That is, in fracture with laceration or compression of the cord by displaced bone, there is usually hemorrhage in or around the cord, always followed by edema, and often later by narrowing of the cord space by new bone growth or scar formation. However, in nearly every instance one factor, such as compression by bone or hemorrhage in or about the cord, so predominates as to render the other factors negligible for the time being, though later these other factors will add their quota to the sum total of the symptoms and have a strong effect on the result. It must not be forgotten in making a diagnosis and determining the probable factor or factors in the causation of the cord signs that, as mentioned above, immediate interruption of conductivity, whether partial or complete, does not necessarily mean laceration of the fibers or tracts interrupted.

One stated objection to the early operation, or in fact to any operation in the absence of deformity, is that in many reported instances of early laminectomy, little or no improvement followed, though no displaced bone was found; "and as the cord appeared normal, the dura was not opened." Such observations are similar to those regarding so-called cranial decompressions when the dura is not opened. Compression of cord fibers by edema will not be relieved by the removal of the laminae alone. Just as in head injuries, removal of bone will not relieve the intracranial pressure unless the dura is also opened, so in spinal fractures, a free opening of the dura is most important and should always be made.

It is said by many surgeons that early laminectomy adds insult to an already damaged cord, and yet these surgeons advise in mid-cervical fractures with danger of involvement of the fourth cervical segment, the spinal center of the phrenic nerve to the diaphragm, immediate operation to prevent respiratory trouble.

Immediate loss of power and sensation in parts of the body below the fracture points to the laceration or the section of the cord. Here the indications are for an early operation, not for the sake of the destroyed fibers, but with the view of warding off the compressive effects of the fast following edema, thus preserving the sound fibers and giving the best chance of recovery to the fibers damaged but not destroyed.

Therefore, I believe that in every patient having a fracture of the spine with damage to the cord, excepting only those conditions with signs of very slight cord involvement followed by immediate improvement, and at the other extreme those fractures showing complete obliteration of the bony canal, an early laminectomy is urgently indicated to relieve the cord of the damaging effects of bone pressure, hemorrhage and edema and to give the nerve tissue the best possible chance for repair.

By the term "early operation" is meant a laminectomy after the patient has rallied from the initial shock of the injury. Naturally, if the injury has been so severe or if the patient's vitality is such that he cannot rally from the condition of shock any operation at this time will hasten death. A safe general rule to follow is not to operate while the pulse is above 110. The operation should be performed as soon as the patient has reacted from the shock and the site of the injury is localized. A free opening of the bony canal will relieve compression by bone, whether due to driven-in laminae or a backward projecting vertebral body causing angulation of the cord. If a projecting vertebral body presses against the cord in front in spite of the removal of the laminae, sufficient bone can be chiseled or rongeured away to give the cord ample room. A free opening of the dura will permit of removal and drainage of blood, and will offset the compression effect of the subsequent edema. The dura may be reclosed or not as indicated by the condition of the cord. In very many cases it is best left open. The technique of the operation is briefly as follows:

A single incision is made in the median line down to the tips of the spinous processes. The muscles are then incised close to the spinous processes, down to the laminae on each side and the incisions packed with hot wet cloths to prevent bleeding. The laminae are freed of muscle by a broad periosteal elevator and a self-retaining retractor is then inserted,

which gives good exposure and effectually prevents bleeding. The spinous processes are removed by large special rongeurs and the laminae are rongeured away out to the transverse processes, giving a good exposure of the canal and cord. Bone fragments, if present, are removed, before the dura is opened, and any portion of a dislocated vertebra projecting far into the spinal canal is removed by rongeurs or chiseled away. The opening of the dura and arachnoid allow for escape of blood or serum, and if the cord is tense and swollen a small longitudinal incision carefully made in the posterior column will afford drainage. A drain at either end of the wound extending to the dura, or at least to the bottom of the muscle wound will provide an escape for wound fluid. The wound is closed by layer sutures to obviate dead spaces. A narrow posterior splint to the spine will prevent movements of the trunk and give the patient much comfort. When he is able to get about a plaster jacket is applied to be worn for at least a year.

What shall be done in those instances in which at operation the cord is found completely divided? It is almost generally agreed at the present time that cord fibers once severed do not regenerate. Murphy said that if the cord is severed, approximation will avail nothing. However, of the five instances reported of severed cords sutured, four were living several years after operation, while without suture no patient has lived over a year. The great improvement following suture, in the sensory and trophic disturbances, thus averting the terrible bed sores, warrant sutures for this alone. I believe that suture of a severed cord should be attempted. While I believe this to be the proper procedure, it will not often be found feasible to attempt it in fracture. For in this condition the cord is rarely cleanly cut, but is apt to be crushed for a variable distance, a distance too great to be bridged by sutures. If the ends cannot be approximated and the lesion is in the dorso-lumbar region an attempt should be made to unite the roots above and below the lesion, as suggested by Basil Kilvigton. This cannot be done in the upper dorsal or cervical region because of the short course of the roots in the canal.

Summary of Advantages of Early Laminectomy.

1. It removes pressure from the cord, whether due to depressed bone or to blood clots.

2. In a fracture-dislocation, it allows the cord ample room, relieving the pressure effects of angulation.

3. It provides drainage of the certain edema, which by its compressive effects is destructive to the nerve fibers.

4. It allows for drainage of blood, if present, the compressive effect of which may be so great as to permanently damage the cord.

5. In skilled hands, laminectomy is not a difficult or dangerous operation, and by doing it early the surgeon has given the damaged cord the best possible chance for repair.

THE BEDSIDE ROENTGENOGRAPHY OF FRACTURES.

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APPARATUS

Previous to the war the portable apparatus utilized was exceedingly clumsy, cumbersome and required considerable skill for successful operation. During the war, there was developed for use in the United States Army a compact and efficient apparatus suitable for the usual varieties of current supply. This unit consists of a cabinet 36 inches high and 24 inches wide, mounted on rubber-tired wheels, and having attached a very complete tube-holding device capable of movement in all directions and retention in any given position. Within the cabinet is a small high-tension transformer of 60,000 volts, and in the base a small inverted rotary converter with a double-throw switch. This apparatus can be attached to the ordinary lamp socket, and if the current be alternating a simple push-button switch turns the *x*-ray on and off. There are no controls, a simple off and on switch being employed. The tube may be excited by a current of 5 to 10 milliampères at about 60,000 volts.

The only factors under control of the operator are time of exposure and distance from tube to plate. If the current be a direct one, the switch is thrown to the other side and the inverted rotary converts the direct into alternating current, and the apparatus works as usual.

The output of the machine is small and its capacity limited, but experience in hospital wards has shown that this little apparatus is capable of making entirely satisfactory roentgenograms of all portions of the body, except the gastro-intestinal tract. Moreover, it is extremely transportable and requires no accessory wiring but can be used from the ordinary hospital lighting circuits. The surgeon is enabled in his fracture cases, for example, to determine the efficacy of his retentive apparatus and the degree of reduction of the fragments with their position, etc.

The secondary circuit contains no rectifying device, since the Coolidge tube for which the unit is adopted rectifies its own current.

For use with these units, Coolidge devised a special, air-cooled, finely focused, small-bulb tube, which possesses the unique property of continuously rectifying high-voltage alternating currents, suppressing one phase and utilizing the admitted phase for the production of *x*-rays. This radical invention at once permits the discarding of the cumbersome synchronous motors and mechanical rotating rectifying switches previously considered indispensable for this purpose. It consists of a glass bulb, containing a practically perfect vacuum. The cathode is a filament of tungsten wire which may be heated to incandescence by a passage of a 12-volt electrical current. Placed within the tube at a distance of about one inch is a copper anode or target faced with a small button of tungsten. This copper target is prolonged as a thick copper rod emerging from the end of the tube through a scaling-in platinum sleeve which provides an air seal and an expansion joint. Attached to the end of the rod, and removable for transportation purposes, is found a series of copper radiating fins, which may be placed in close machanical contact with the shaft. These fins have a considerable radiating capacity, and, due to the conductivity of the copper, carry away and dissipate into the outside air the heat generated by the impact of the electrons against the focal spot on the target. Over the tube is slipped a lead glass sleeve with a single opening for the emission of the ray.

This apparatus, transformer and tube, by virtue of their ease of transportation and simple design have now come generally into use as bedside instruments.

Besides this army type there are numerous other types of apparatus all of which are built upon the same principle. But all operate best when used with the self-rectifying Coolidge tube. All these apparatus have the same parts, an oil-immersed high tension transformer, auto-transformer control, filament regulator, volt- and ampere-meters, switches for main line voltages, and an attachable rotary converter for direct current. They are all operable on 115 volt direct or 110 or 220 volt alternating current. These equipments have no rectifying devise. The alternating, high-tension current is passed directly into the Coolidge radiator tube which rectifies the current, cutting out that alternation which travels in the wrong direction.

When it is necessary to carry the bedside unit from ward to ward, it may be suspended by the handles on a litter made of timbers of sufficient strength and fastened together by two crosspieces. It consists of two timbers 2x3 inches, 5 feet long, set 16 inches apart, and held together by two crosspieces 3 feet apart.

There is one type of apparatus that deserves special consideration. It is perhaps the most compact and efficient unit that has yet been developed as a portable outfit. It contains all the necessary radiographic accessories and is simple in construction and operation. The parts are the same as the unit first described, though separately disposed and to be assembled for usage. The Coolidge *x*-ray tube supplied

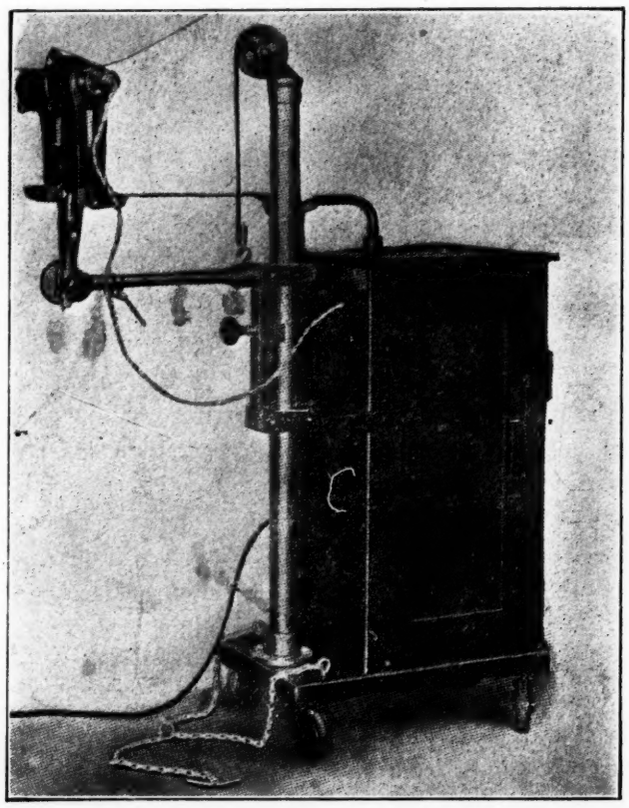

Fig. 1. Portable unit, army type.

with this outfit is of a special type. It is blown of thick glass, with a very high content of lead, 55% by weight, which gives the protection afforded by 1-16 of an inch metallic lead.

The golf bag, containing the tube stand is first opened. The tube stand is removed. The suit case containing the accessories is then opened and the foot screwed to the tube stand. The cross bar is then removed from the front of the suit case and placed in its proper position on the tube stand. The top of the transformer is unscrewed and the transformer placed on the foot plate of the tube stand, with the side marked "right" to the right. The two reels are then removed and placed on the side of the cross arm. The tube holder is removed from the suit case and

screwed to the tube stand. The Coolidge tube which is contained in the rear compartment of the suit case, is placed in the tube holder with the anode to the left, the cathode to the right. The radiator is then screwed on to the anode side but not too tightly. The hook of the reel is attached to the opening in the radiator. The end of the other reel is fastened to the cathode side of the tube. The cable wires contained in the left hand compartment of the suit case are then removed and, if we are dealing with alternating current, the connection is made to the 110-volt lamp socket, then to the three openings in the box containing the switch board. Another connection is made from the other three openings in the switchboard to the transformer. Additional electrodes are attached to the two spherical balls on the transformer to the two reels.

If we are dealing with a direct current the connection is made to the 110-volt socket, then to the direct current side of the rotary converter. Another connection is made from the a. c. side of the rotary converter to the three holes in the switchboard box. Then a connection is made from the switchboard box to the transformer. (Fig. 2.)

To operate, turn on the switch from the socket, then turn on the button marked circuit breaker, and a red light will appear, showing that the connections have been properly made. When operating on alternating current, 10 milliampères at 100 volts is desired. Push the button on the lower right hand corner of the switchboard to start current and filament and note reading on the milliampère and volt meters. If the reading is not as desired, voltage may be either increased or diminished by turning the handle marked "volts". Filament current may be increased or diminished by removing the meshed metal cap on the right hand reel and then moving the metal rod either forward or backward to obtain the desired number of milliampères. There is an attached time switch which has a range to thirty seconds.

METHODS OF ROENTGEN EXAMINATION OF FRACTURES.

1. Transillumination—roentgenoscopy.
   (a) General.
2. Photographic method—roentgenography.
   (a) General examination.
   Single plate target—plate distance, 20 inches
   Centric
   or
   Excentric
   (b) Special examination.
   (1) Stereoroentgenography — two plates made with deviation of tube 2½ inches, the relation of plate to part remaining unchanged.

1. *Roentgenoscopy (fluoroscopy).*

The plate examination is comparatively far more complicated than the fluoroscopic method and requires numerous accessory appliances and, though it has the advantage of permanency and greater accuracy of its records, nevertheless, the simplicity, convenience and rapidity in obtaining results make the fluoroscope an instrument of greater general utility.

The requisites of safe and successful fluoroscopy are: 1, a ray of proper quantity and quality; 2, a screen of proper quality, size and suspension; 3, the proper sensitization of the eye; 4, the protection from deleterious effects. Careful attention to the first three requisites will contribute in a large measure to the establishment of the fourth.

The old fluoroscopic viewing box consisted of a small screen attached to a pyramidal hood of cardboard, the eyes being applied to the smaller end, so that the examination can be made in a lighted room. This has come into vogue again because of military needs. Such a pyramidal fluoroscopic screen has been described by Dessani. It is to be fitted to the wearer's eyes and kept in position by bands across the head. By a hinged arrangement the fluoroscope may be tilted back out of the line of vision. When so used, the observer looks through a layer of ruby or green glass, which permits operative procedure without desensitizing the eyes.

Too great emphasis cannot be laid on the problem of protection, particularly when using the portable equipment in which the tube is not very carefully covered. The roentgen ray is an agent capable of causing considerable damage to the organism. Though this appears to be generally appreciated, it is nevertheless surprising to note the utter disregard of this danger during fluoroscopy, particularly with the use of the Coolidge tube, when many of the limitations which gave a certain margin of safety when the Crookes tube was used, do not exist. Carelessness in providing suitable protective measures is bound, sooner or later, to lead to disastrous results. It must not be forgotten that the late skin effects may, and usually do, come on from four to seven years after prolonged exposure. Immunity from such effects for a year or two instils a false sense of security. Eternal vigilance is the price of an intact skin. Such additional protective devices as lead-rubber gloves are essential and ordinary leather gloves

should be worn underneath the rubber gloves. This is particularly important if fluoroscopy be used for the reposition of the fragments. Lead glass goggles and leaded aprons are useful in further increasing the safety of fluoroscopy.

Besides these dangers from the ray itself, there are other hazards which must be guarded against from the installation itself. There seems to be a notion prevalent that because these portable apparatus are small, they are harmless. But this is a serious error. The apparatus is capable of delivering 60,000 volts at 10 milliampères, and under certain circumstances may cause serious damage and even fatalities if the body comes into contact with the discharges. Because these machines are coming into common usage and are in the hands of those not specifically trained, a word of warning is perhaps in place.

It is important that all metal parts of the outfit, such as the switchboard, table, tube stand and particularly the tube box and handles controlling the movements and diaphragm, should be effectually grounded. For this purpose a flexible cable is preferable to a rigid wire, which may break or become disconnected. Wooden floors are safer than concrete for the operator. Concrete should be covered with some suitable material, such as rubber, wood, thick linoleum.

When operating *x*-ray tubes, there should be no loose or slack wires; all connections should be taut and kept so by a spring and whenever possible heavily insulated wires should be used, but even those should always be treated with the same precaution as a bare wire, because the insulation for high tension current is rarely perfect.

All connecting wires of the high tension apparatus must be out of easy reach and so guarded that assistants or patients cannot come in contact with them. These wires should be examined from time to time, and precaution should be taken so that a live wire cannot fall on the patient or operator.

It is good to plan to eliminate all overhead wiring in hospital wards or the small *x*-ray rooms. But when such a trolley system must be used, all wires leading from the high tension apparatus to the overhead lines must be periodically examined.

Great care should be taken that all fuses carry only the maximum current required by the apparatus, so that any overload or earth leakage will immediately blow the fuse. Too much dependence should not, however, be placed on these, for they will often carry an overload before blowing.

Care should be taken that the metal extremities of the tube be not too close to the patient. All metal applicators should also be grounded. Sand bags are best for checking the involuntary movement of patients.

An arrangement that allows of two pieces of apparatus to be simultaneously connected to one high tension source should be avoided. The absence of a commutating devise makes the bedside apparatus noiseless, therefore the high tension wires should never be touched without first shutting off the current. When examining and testing an installation it is not enough to merely shut off the main switch on the apparatus, but it is also important to open the switch at the main supply.

The apparatus should not be installed in a room too small or in a narrow space between beds. It may become dangerous to move about.

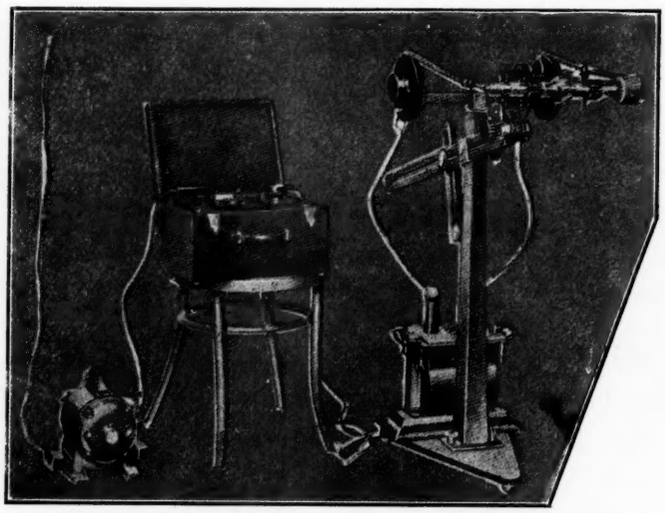

Fig. 2. Bedside arrangement of Coolidge portable radiographic unit for direct current. For alternating current the rotary converter, on the left, is not needed.

If possible, there should always be an assistant about, who is familiar with the position of the main switch.

The quality of the tube should be of sufficiently high vacuum to permit a clear differentiation between bone cortex and medulla. What should be sought for is detail with sufficient contrast. Should it be necessary to move in and out of the fluoroscopic room, colored glasses should be worn. The observer should remain in partial darkness for at least ten minutes before the first examination is begun. The visible light from the tube itself must be eliminated. The static glow of the wires carrying the high tension may be eliminated by the use of a tin or iron piping or heavily covered cable. This holds only when the open screen is used.

The foot switch should be placed in a convenient

situation and permit the control, not only of the energization of the *x*-ray tube, but the general lighting of the room.

It is a foolhardy and useless procedure to fluoroscope a patient over a long period of time. The energizing of the tube must be intermittent:—a glance and then an interval for orientation and thought; then another period for observations, followed by a period of darkness, for consideration as to what is observed and what is to be sought or still to be determined. By this method the interest of the patient is safeguarded and prolonged exposure is avoided.

Working with a gas tube, whose equivalent spark gap value is six to seven inches, or with a Coolidge tube of five to six inches, and using two to five milliampères of current, through one millimeter of aluminum, an exposure of ten minutes is the limit of safety at the usual target-skin distance, if a skin reaction is to be avoided. With the constant moving of the body of the patient, incidental to the examination in all directions, no part should, therefore, ever receive a large fraction of a dose.

The disadvantages of fluoroscopy are:

1. The overlooking of fissures and fractures where there is no displacement of fragments or fractures of carpus or tarsus.

2. Exaggeration of deformity by distortion of shadows.

3. Damages of exposure.

4. In operative work, the dangers of explosion from the ignition of the anesthetic by electric spark.

When patients are either too sick to be moved or even turned upon their side or else, by reason of being splinted or slung in Balkan frames they can not be moved, they may be fluoroscoped directly in bed by the use of four stilts, which, when placed under the legs of the bed, raise it twelve inches; the tube can be dropped beneath the bed and fluoroscoping through the mattress secures very satisfactory information. The bed springs of the regulation bed do not interfere materially with the study because, being some distance from the screen and a greater distance from the screen than the tissues to be examined, the mesh casts a much exaggerated shadow, which does not interfere with visualization of the part.

By the method even the sickest patient may be examined without the position of the fractured limb being disturbed. Where the Balkan frame is used, the frame, which is lashed to the bed, is lifted with the bed and rests with the legs of the bed on the stilts.

The commonest errors arise from the following causes:

1. When the parts are incapable of immobilization.

2. When the affected parts cannot be placed in close apposition to the plate.

These errors may be avoided by a careful attention to technique. The immobilization of the part is important because the movement may so blur the bony outline as to make it impossible to definitely determine the fracture line, particularly where long exposure must be used as with the portable unit. This is particularly so in the determination of fractures of the skull in children or in fracutre of the ribs or about the shoulder joints.

When immobilization is impossible, rapid exposures must be resorted to by the adjuvant means of a double intensifying screen and a film. Everything which makes for the comfortable position of the examined limb aids in immobilization. This may be accomplished not only by weights, sand bags, bandages, adhesive plaster, pads, and inflated rubber bags, but also by certain positions of the body by which the affected part is put at rest with the muscles relaxed and made to approximate the plate as closely as possible. Any portion of the forearm or arm to be examined properly must be placed at the level of the shoulder. For the examination of the leg it is necessary that the thigh muscles be relaxed. Frequently exposures must be made with parts in suspension apparatus and in such a position as makes approximation of part to plate impossible. To minimize distortion where approximation of plate to part cannot be obtained, the distance from tube to plate should be increased.

3. When there exist no changes in form and outline of the bone nor any displacement of fragments.

In the examination of fractures there are two considerations: (a) to determine the presence of a fracture; (b) to determine the degree of deformity. These two conditions cannot always be met with the same examination, since it is frequently necessary purposely to distort the outlines of the bones in order to determine the presence of a fracture. This gives an exaggerated and false picture of the deformity. The latter condition should be judged by a normal exposure. Thus spiral supramalleolar fractures of the lower end of the fibula even with slight displacement of fragments will be frequently overlooked in the normal antero-posterior or lateral exposures. An oblique view, however, gives the entire length of the malleolus and displays such a fracture prominently.

Thus the scaphoid must be placed with its longaxis parallel to the recording surface by ulnar deflection of carpus and abduction of the thumb, if fractures of this bone are always to be discovered.

4. When the examination cannot be made, or is made only with difficulty, in more than one direction. To study deformity in undisputed cases of fracture under these circumstances, consideration must be given to the relative sharpness of the fragments at the point of fracture, bearing in mind the axiom that the nearer to the recording surface an object is, the sharper and truer its shadow. Thus, in antero-posterior sagittal views, the sharper fragment is the one which is displaced posteriorly. This determination often becomes necessary in fractures about the upper end of the femur or humerus. The stereoscopic examination is here of great assistance.

5. When the fracture is in that axis of the bone that makes the examination in a plane perpendicular to the axis of the bone impossible.

These errors may be avoided also by a stereoscopic examination, which is particularly valuable about the joints, to study the direction and extent of fissures and to seek the important information, which is not always easy to obtain, if the fissure extends into the joint. Frequently, however, fissures parallel to the axis of the bone will escape detection and when clinical evidence is strong, it is advisable to wait two or three weeks and then the callus, at the suspected point, makes the diagnosis clear.

Indirect evidence is often valuable as indicating fractures. With a history of trauma, if the shadow of the fifth lumbar vertebra has a marked obliquity or cannot be outlined at all, a fracture should be suspected. Fractures of the articular processes of the vertebrae may be suspected when the malposition of the bodies exists as shown by a change in the alignment of the spinous processes. If, in a suspected case, both the transverse processes of one vertebrae are narrowed and its axis deviates from that of the vertebrae above and below, one must suspect a fracture of the body of the vertebrae. A fracture of the pelvis may be suspected from the hip plate by a study of the lower end of the sacro-iliac synchondrosis. The sacrum, like the keystone of an arch, registers any break in the arch by a slipping and consequent distortion of the sacro-iliac joint space, the lower part of which should show a normal hip exposure.

6. When the fractures are multiplex and at extreme ends of associated bones, as the upper end of the fibula and lower end of the tibia.

The error of overlooking one of several fractures may frequently be placed at the door of the clinician whose cursory and unsatisfactory clinical examination confines the *x*-ray examination to a certain part of the limb. This is particularly true in hospitals and laboratories where a localization of the lesion is requested in order to facilitate the examination. The roentgenologist, however, has certain findings which warn him that other fractures should be looked for: for instance, a fracture of the tibia low down with marked displacement of fragments usually is associated with a fracture of the fibula high up. The fracture of the lower end of the ulna usually is associated with a fracture of the radius. A fracture of the pubes usually is associated with a fracture of the ilium. A fracture of the os calcis frequently is accompanied by a fracture of the internal malleolus of the tibia or of the metatarsal bones. In injuries about the wrist, scrutinize the lower end of the radius, the styloid process of the ulna, the base of the first metacarpal and carpal scaphoid.

7. When the fracture lines are mistaken for artifacts, soft tissue folds (axillary and anal) calcifications of bursæ or tendons, epiphyseal lines, epiphyseal scars, supernumerary bones, the os trigonum being mistaken for fracture through the posterior process of the astragalus, os peroneum for cuboid fracture, os vesalianum for fracture of the base of the fifth metatarsal and os triangularis for fracture of the styloid process of the ulna. Sesamoids may be mistaken for fragments of a fracture and pulmonary markings for fractures of the ribs, the line of the psoas or fracture of the transverse processes of the vertebræ.

8. When the examinations are made through heavy casts or heavy board splints. Under these circumstances the exposure should be doubled without a change in the quality of the ray. Subperiosteal fractures and callus formation about complete fractures are frequently undeterminable when heavy casts have been applied, particularly so if the casts are wet.

9. By looking and not seeing. This is easily remedied by a slow and careful perusal of the entire bone length and by a refusal to be rushed into the diagnosis of a wet or dirty plate. Make as studious a contemplation of the plate as the surgeon does of the patient.

It is a wise rule to inspect the patient's hand within 12 hours after applying splints or plaster cast to the arm or, especially, the forearm. If these are, or become, too tight an irreparable Volkmann's contracture may be produced within 24 hours.

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WALTER M. BRICKNER, M. D., F. A. C. S., Editor.
New York City

ELMIRA, NEW YORK, MAY, 1921

FRACTURES.

It would not be difficult to trace the various factors that have stimulated to its present pitch the surgeon's interest in the treatment of fractures. Some of these come to mind at once: the routine employment of roentgenography, the important work of Sir Arbuthnot Lane, the valuable contribution of Lucas-Championnière, the increasing attention of the medical profession and of the State to industrial accidents and to the functional restoration of the injured, the reports of the Fracture Committees of the American Surgical and the British Medical Associations and —by no means least—the intensive study, during the war, of the management of fractures as they occurred with "gunshot" wounds.

It was because of the unsatisfactory results that often followed various methods of splinting, especially in fractures of the humerus, the femur and the tibia, that Lane easily evoked an enthusiasm for the operative treatment not merely of ununited and malunited fractures, but also for recent, simple fractures. We believe that this enthusiasm has waned, not only because plates, clamps and screws are foreign bodies that often delay union and produce other troubles, but because we have learned other, less risky, methods by which, in most cases, good position can be secured and maintained. Open reduction will continue as a necessary procedure in many cases, but these are the exceptions and not the rule.

The perfect reposition of bone fragments is a mathematical ideal, not a surgical necessity. The objects to be sought in the treatment of a fracture are: the contacting of the broken ends; "adequate" reduction, i. e., without shortening or without material shortening; the avoidance of angulation, of axial rotation and of injury to soft parts; the preservation or early restoration of function. All of these objects can be attained, in most cases, without converting, by open operation, a simple into a compound fracture.

The plaster of Paris cast is perhaps the most useful immobilizing means for fractures in general. We have learned, nevertheless, that it is not usually satisfactory in fractures of the shaft of the femur; however well reduced, e. g., on a Hawley table, overriding of the fragments is apt to recur despite a plaster cast. In fracture of the humerus, too, the cast or moulded splint, without continued traction, is usually insufficient. By adequate traction, however, overriding can be overcome, gradually or at once, in many femur cases completely, in most cases within an inch; while by proper direction of pull, and the proper position of the limb in a suspension support, angulation and rotation are controlled under the eye.

The revival and elaboration of the traction-suspension treatment of fractures of the thigh and the leg came about in the war through the necessity of exposing for dressings the large wounds by which these injuries were compounded. But the beneficence of this mode of treatment in simple fractures also became evident. The application and development of the method to fractures of the humerus was the work of Col. Blake, who has reviewed the principles and the technic of his procedures in this issue of the JOURNAL. The application of traction-suspension in fractures of the tibia is described in the excellent article by Moorhead; and its indications in the management of intertrochanteric fractures are presented in Kellogg Speed's elaborate study of that subject.

One of the advantages of traction-suspension treatment is that it can be arranged to maintain mobility of the joints. Blake has emphasized this in connection with the use of the method in fractures of the humerus. In fractures of the femur the knee may be left free, either from the outset (by employing the Steinmann nail, the caliper tongs or the Hennequin loop) or after a few weeks, by replacing the adhesive strips with a Hennequin loop above the joint or applying the strips to the thigh only. Most

surgeons, we believe, are of the opinion that prolonged immobilization of a joint stiffens it and greatly retards restoration of function. Dr. H. Winnett Orr, on the other hand, believes that complete immobilization is preservative of joint function. We invited him, therefore, to submit his arguments in this issue of the JOURNAL, and we present them to our readers for their consideration.

After applying a plaster cast to a fractured thigh or upper arm the surgeon has nothing to do until the time arrives for its removal—when he can take note, all too late, of its shortcomings. The traction-suspension treatment is not so easy; it requires much attention throughout, and especially the first week. The surgeon who has not the inclination (indeed, the enthusiasm), and the time, to "fuss over" its details, and to control his results by frequent bedside roentgenography (not only until he has secured the best attainable position but also from at intervals thereafter), had better turn the case over to a surgeon who has.

Major fractures involving the ankle joint are among the most difficult to manage. Unless they receive optimum treatment, Pott's and similar fractures or, more properly, fracture-dislocations of the ankle, are often crippling. We commend the careful study of the contributions on this subject by Estes and by Cotton, members of the Fracture Committee of the American Surgical Association. Both articles are excellent. Than Cotton's one would have to look far, indeed, to find one more clear and concise, more straight-to-the point concerning diagnosis and treatment.

Fractures about the elbow are also apt to interfere with joint function. In this connection one thinks especially of fractures through the ends of the humerus or the ulna. But fractures of the upper end of the radius, sometimes not recognized, may also prove crippling. They are not as fully described in the text-books as other injuries to the elbow; and so we are very glad to present here the excellent detailed study of Hitzrot. His classification of upper radius injuries is very interesting, the more so since it affords a basis for treatment and for prognosis.

We do not mean to refer to all the contributions in this special issue of the JOURNAL. Written by experts, for the purpose, and upon assigned topics, they are all admirable. To be sure, they do not cover all the fractures to which the human skeleton is subject, but they do deal with the most important fracture-groups; and they present very clearly the principles in treatment, the choice of methods. We believe we have reason to be proud of this issue of the JOURNAL. We believe, too, that it will be read through with interest and profit, and preserved for future reference.

Fracture Suggestions

Extensive, early ecchymosis after a trauma is very suggestive of a fracture.

Localized tenderness after a trauma is also suggestive of a fracture.

After an injury to the head take note of the occlusion of the teeth, with the jaws closed naturally, and with the upper and lower incisors brought into line. A deviation, even slight, of the line between the lower central incisors to one side of the line between the upper central incisors, suggests the possibility of a fracture of the mandible, and it may be the only sign that the patient then exhibits. However, a slight deviation is habitual with some individuals.

Subcutaneous emphysema of the chest, with fracture of a rib, means, of course, that the lung has been lacerated or punctured. It is important to determine then, by physical signs and roentgenography, whether there is also an accumulation of blood in the pleural cavity. Unless such a hemothorax be small in amount, it is usually advisable to evacuate the blood with a large needle or small trocar, after allowing sufficient time for hemorrhage to cease.

Fracture-dislocation of the upper cervical vertebrae without injury to the spinal cord is not rare. In such cases attempts at reduction involve grave risk of producing what the patient has thus far escaped. It is wiser to let well enough alone.

After an injury to the back, persistent pain in the lumbar region, or root pains elsewhere in the body, may be due to a fracture of a vetebra undiagnosed at the outset and undemonstrated by roentgenogram.

A congenital cleft in one or more of the lumbar or sacral vertebral arches is not uncommonly seen in roentgenograms. Such a cleft is occasionally oblique, narrow and unilateral. It should not be mistaken for a fracture.

In old people pain and disability in the arm after a trauma call for a careful examination of the shoulder. Fracture of the head of the humerus is often overlooked.

In cases of fracture of the anatomical neck of the humerus, examine carefully for injuries to the brachial plexus.

Fracture of the greater tuberosity of the humerus is usually followed by a long period of shoulder disability if the injury is treated by fixing the arm in an adducted position. It should be treated in *abduction.* This is most simply and most comfortably accomplished with the patient in bed—continuously or intermittently—, the arm abducted on pillows and supported by a sling from the elbow to the head of the bed. After about three weeks light Indian club exercises are useful to secure full and free movements at the shoulder.

Fracture of the head or either neck of the humerus is also best treated by abduction in bed, with such rotation of the arm as will secure the best axial alignment. Fixation in plaster is not necessary. Indeed, it will result in more disability than treatment without such immobilization.

When a child who has been pulled by the arm has disability in that member, attention should first be directed to the upper end of the radius. There will probably be found a subluxation of the head of the bone ("pulled arm") or an epiphyseal separation. The "pulled arm" often jumps into position during examination, and the disability at once ceases.

It is wholly wrong to treat a Colles' fracture by continuous immobilization of the forearm and hand for several weeks. After reduction there is little tendency to displacement. Light, supporting, molded splints are sufficient. The fingers and thumb should not be splinted or bandaged; their free movement should be encouraged from the outset. Before the end of the second week the splints should be removed every day or two for massage and passive movements of the wrist. In the third week the dorsal splint can usually be dispensed with, and the palmar splint shortened sufficiently to permit wrist movement. Indeed, in many cases of Colles' fracture Moore's adhesive plaster support-sling is all the retentive appliance that is necessary. The chief factors in securing a good result in Colles' fracture are, first, reduction and, second, preservation of wrist function by massage and exercises.

Fracture of the anterior superior spine of the ilium occurs occasionally, especially in adolescents, as the result of sudden muscular violence—as in springing forward from a crouching position in a foot-race.

Simple inspection is sufficient to make a diagnosis of fracture of the neck of the femur. Shortening of the extremity, elevation of the trochanter and external rotation of the foot are eloquent signs. Manipulation adds nothing except pain!

Fracture of the base of the fifth metatarsal is not a rare accident, as the result of twisting the foot in walking or dancing. The lesion is often mistaken for an ankle or tarsal sprain.

Progress in Surgery

Selections from Recent Fracture Literature.

H. Lyons Hunt, M.D., L.R.C.S., Abstract Editor

A British Medical Association Lecture on The Influence of the War on the Modern Treatment of Fractures. HENRY WADE, Edinburgh, *The British Medical Journal,* March 5, 1921.

The author calls attention to the fact that a fracture during the war was a matter of team work, the regimental medical officer being the family doctor of his battalion. His duties were also those of an instructor imparting to units of his regiment information relative to first aid. The duties of the regimental medical officer were to cover the wound to prevent it being further contaminated, to relieve pain, to arrest hemorrhage, to provide rapid and comfortable transport and to minimize shock.

In cases of fracture of the femur, the first splint consisted usually in the application of a rifle to the side of the thigh to immobilize it. Later the Thomas splint was applied. This splint had a number of advantages. It sufficed for the transport of cases not only of fracture of the femur, but in injuries of the lower extremities. The simplest and best bed-frame in the author's experience is the Morison R. I. E. bed-frame.

Fracture Reduction and Fixation with a Specially Designed Band. ASA W. COLLINS, San Francisco. *Archives of Surgery,* March, 1921.

In historical review of this subject, the author shows that the early Egyptians used splints and employed open operations. Treatment by the open method is preferable in certain types of fracture associated with comminution such as fracture of long bones, fracture associated with wide separation of the fragments by muscular pull of the interposition of soft parts.

The mortality of the operative method of reduction is so small that this cannot be used as an objection to the method and in cases where there is no objection to the open method of operation, the operator must decide on the best method, plate, wire band or bone graft.

After briefly considering the physiology of bone and the repair of fracture, Collins deduces that the essential consideration in selecting a procedure, is to consider the effect of the bone splint or band on the periosteum and its function in repair.

Believing that the Lane plate was fundamentally wrong, the author devised a band which would not encircle the bone at any one point in the circumference, but would give perfect

apposition of fragments without any foreign body being introduced into the bone substance proper.

His objection to plates is that they cover a large surface of periosteum, are bulky and depend for results on screws driven into the cortex. The screws frequently become loosened, and as a result the plate's grasp is weakened, infection ultimately developing.

The objection to the Parham band, bands devised by Milne, Lambotte and Rexwald Brown, is that to a greater or less degree, they constrict periosteum as also does wiring.

The band devised by the author is placed on the bone with a special applicator. He gives results of experimental studies on 75 rabbits which warranted him using the band on the human subject, and from case reports gathered to date, including more than 100 fractures, the humerus and femur have been operated on in all but 7 cases, the band removed in 8 cases, 4 of these because the operator objected to allowing any foreign material to remain in the tissues, infection occurring in 5 cases, each being a compound fracture.

The author concludes:

1. The band is more quickly applied than screw plates, bone grafts, kangaroo tendons, medullary dowels, etc.

2. It furnishes sufficient force under easy control to bring the parts into apposition and is of sufficiently strong mechanical construction to immobilize them.

3. It provides a simple means for fastening without disarranging the tension or position of the band or the fragments.

4. Through its use, a circle of unyielding pressure at any one point is avoided; and the band adapts itself to an uneven flaring surface.

5. The band is compatible with a good callus formation.

6. It has no deleterious effect on growing bone, but on the contrary, it stimulates growing bone. (Further experiments to establish just why this should occur are now in progress).

7. And lastly, it affords greater satisfaction to the operator even in those cases in which normal function might be assured with a lesser degree of coaptation, especially in cases related to accident insurance, the Workmens' Compensation Act, damage suits, etc.

A Concept of X-Ray Pathology. Fractures. A. J. PACINI, Washington. *Medical Record,* March 19, 1921.

For purposes of *x*-ray pathology, the author divides fractures into those of flat bones and those of long bones. The flat bone fractures involve the skull and vertebra. He classifies fractures of the skull in the usual manner and states that linear fractures occasion a radioparent line if both tables are involved, a radiolucent line if only one table is involved and must be differentiated from suture lines, diploic vessels and arterial grooves.

Depressed fractures may be bounded by radiopaque margins. On account of basal fractures being frequently overlooked, he advises that vertical projection of the base in addition to an anteroposterior, posteroanterior, sinistrodextral and dextrosinistral views, should be taken in each case.

Vertebral fractures are recognized in *x*-ray pathology by the deformity produced in the body of the vertebra. Pathology involving the fifth lumbar vertebra should be expressed with caution. He divides fractures of the long bones into those affecting the diaphysis and those affecting the epiphysis.

The author decries the fact that callus formation does not appear to receive the amount of attention that it should. In children in diaphyseal fractures it appears about the tenth day; in adults calcium salts being deposited usually at the end of three weeks, while in old people the same change does not commence until six weeks.

In freshly sustained fractures the roentgenologist should report not only in terms of the anatomical part affected, of the variety of the line of fracture, of the direction of the upper and lower frament and of the presence and absence of overlapping, but he should take such views of the fractured part as are necessary in establishing definitely the disturbed balance of muscle group pull responsible for the deformity, with the view to guiding the surgeon in the correct alignment of the part of traction for obtaining the zero position in the correction of the injury sustained.

Fractures of the Base of the Radius (Colles' Fractures). ROSCOE C. WEBB, Minneapolis. *Minnesota Medicine,* March, 1921.

In the history of this fracture, the author draws attention to the fact that previous to 1783 it was considered as a dislocation and was first described as a fracture by Pouteau in that year. His views were denied recognition as were those of Colles in 1814 until 1830. The writer calls attention to Hitzrot's explanation of this fracture into three types: "A" type follows the line of ossification between the diaphysis and epiphysis and is about 1.75 to 2.25 cm. above the radio styloid. "B" type has the line of fracture entering the radioulnar joint. "C" type is 3.75 cm. or more above the radial styloid and is found in young people. (AMERICAN JOURNAL OF SURGERY, February, 1921.)

Reduction in anesthesia is important. Waiting for swelling to subside before reduction is poor therapy.

In conclusion the author states: Colles' connection with this fracture is purely of historical interest, and the substitution of the term fracture of the base of the radius will promote progress in study and treatment.

The fractures result from a combination of compression and extension and vary with the manner of falling and age of the patient.

These fractures should be considered as emergency cases and reduced at once under anesthesia.

The surgeon should interpret the *x*-ray plate himself and treat each case as indicated.

Deformity and impairment of function depend upon:

(a) The character of the line of fracture
(b) The age of the patient
(c) The time of reduction
(d) The character of reduction
(e) After-treatment.

Delayed Union and Non-Union of The Radius and Ulna. H. W. MEYERDING, Rochester, Minn., *Minnesota Medicine,* April 25, 1921.

While the failures of some fractures to unite may be due to faulty reduction and incomplete fixation, the interposition of periosseous structures, necrosis, loss of bone substance and impaired blood and nerve supply, there is a group in which neither syphilis nor any of the foregoing factors appear, but in which the process of ossification ceases before union is complete.

Fifty-nine patients with delayed union or non-union were observed in the Mayo Clinic from May, 1913, to June, 1920; the average length of time since fracture was more than fifteen months.

Meyerding describes in detail with illustrations a bone grafting operation favoring massive graft held by beef-bone screws and external fixation by plaster casts. The splints should be maintained until roentgenographic evidence proves that strong osseous tissue has formed and then the graft should be subjected to careful increasing use so that it may grow in size and strength equal to the strain required for function.

Meyerding reporting five cases with illustrations, concludes:

1. The massive bone transplant has given the most satisfactory results and may be held firmly by means of beef-bone screws.

2. The flat internal surface of the tibia supplies a graft of almost any required size and shape, and with medullary bone rich in osteoblasts allows a wide approximation which insures early union.

3. Fixation by a plaster of Paris cast from the fingers to the mid-humerus is a satisfactory method.

4. Fixation should be maintained until firm union and a strong bridge of bone are demonstrated.

5. The arm should be used gradually on removal of fixation, as the graft fractures when it is subjected to sudden and too great stress.

6. Fractured grafts may reunite when given further fixation.

The Hodgen Splint in Fractures of the Femur—Technic of its Application. F. E. CLOUGH, Lead, S. D. *The Journal-Lancet,* March 15, 1921.

Having used the Hodgen splint for forty years at the Homestake Mining Company's hospital at Lead, S. D., with uniform success, Clough describes in detail its proper application and installation.

The splint consists of two principles, extension and suspension. The first is secured by a Buck's adhesive plaster or flannel strips applied with glue. If adhesive plaster is used, the leg should be shaved. If glue is used no shaving should be done. When applying Buck's adhesive three-inch plaster is split into three tails as far as the ankle and applied very carefully to the leg and thigh. Two or three strips of adhesive are then wrapped corkscrew fashion around the leg and the whole covered with muslin bandage. Advise is given to rub the strips smooth, allowing them to remain for a few minutes without any pull, in order to become firmly adherent. To prevent the strips pressing into the malleoli, a spreader board about four inches long is placed in the adhesive plaster as it goes around the foot. When not using adhesive, Heussner's glue, composed of:

resin—50 parts,
alcohol—50 parts
(pure) benzine—25 parts
Venice turpentine— 5 parts

is substituted. The strips, regardless of where the fracture is located in the femur go at least five inches above the knee or higher if the fracture is above that point.

A cradle is next made of strips of bed-ticking, ranging in width from three to five inches fastened onto each side of the frame of the Hodgen swing, and while supporting the frame with a bridle, the strips are pinned to conform to the contour of the leg and thigh. The cradle should extend from the crotch almost to the ankle. The foot of the bed is next elevated six inches and the loop of the Buck's extension as it goes around the foot is securely fastened to the bottom of the frame with two pieces of muslin bandage. From a ceiling hook placed eighteen inches beyond the foot of the bed, there is dropped a pulley rope equipped with a tent-block which is fastened to the rope bridle of the swing. This produces more or less extension according to where it is tied to the swing. Failure of successfully handling such fractures is due to lack of attention to keep the foot at a right angle with the leg and a right-angled wire foot-piece with a bandage covering is fastened to the frame.

The reader is cautioned against changing dressings too often in handling fractures.

The swing should be utilized six to sixteen weeks, depending upon the location of the fracture. Those of the neck of the femur require the longer time. The walking Thomas splint is recommended for convalescent cases. The writer gives morphine during the first few days of treatment and advises that the fractures should be checked up at regular intervals with *x*-ray findings.

Fracture of the Femur; A Simple Method of Extension. B. F. PENDRED, Loughton, Essex. *British Medical Journal.* March 12th, 1921.

Pendred advocates a method for fracture above the middle where the upper fragments is flexed forwards. In such cases the patient is placed in bed, on his back, the head and shoulders being supported by two or three pillows. The knee of the injured limb is raised until the femur is at the required angle which is generally about thirty to forty degrees to the horizon. It is maintained in this position with a knee pillow, or better still by a pyramid of sand-bags. A ring-shaped air-cushion is slipped over the foot drawn up to the knee and inflated as fully as possible, the foot being allowed to fall back on the bed. A strong bandage is tied around the air-cushion exactly opposite the knee and the other end carried to a pole or mast fitted to the foot of the bed; strong traction is made in the line of the upper fragment, lower fragment, diameter of cushion, bandage and point on mast, until the ring becomes definitely oval, when the bandage is fixed to the mast.

The advantages of this method are:

1. Simple apparatus. A few pillows, a long piece of stick, a bandage and a ring air-cushion or inner tube of a motor tire. Such things can be obtained almost anywhere at very short notice and there is no need to keep apparatus of various sizes in stock.

2. Ease of application. No skilled assistance required.

3. Once fixed adjustment is seldom required. The bedclothes are arranged so that the ring cushion is uncovered and visible, a glance at its shape informs one immediately of the degree of tension and inflation.

4. The foot, hanging over pneumatic pad, acts as a kind of rudder and prevents rotation of the lower fragment, or if desired, it can be pushed inwards or outwards, rotating the lower fragment in any required direction.

5. There being no pulleys, guy-ropes, weights or iron frame, there is very little necessity for disturbing the patient, which saves much anxiety and suffering. A bed slipper is easily adjusted.

6. The thigh is supported underneath by sand-bags, and others may be used at the sides if required to give a sense of security, but these are not necessary. The thigh can therefore be fully exposed, permitting easy examination, dressing and massage of suitable type, all without any disturbance of the fragments whatever.

Compression Fracture of the First Lumbar Vertebra With Delayed Symptoms (Kuemmel's Disease). RUDOLPH V. GORSCH, New York City. *Annals of Surgery,* March, 1921.

Gorsch reports a case of a male aged fifty-six who three months before coming under his care sustained an injury of the back. Roentgenograms were taken which revealed no fracture. Two months later pains recurred in severe form, and accompanied by numbness along the lower border of the ribs; and a "hump" was noticed at the site of the injury. The examination revealed in the lumbar region of the spine a distinct kyphos. Indistinct vertebral spine, limited motion, tenderness on deep pressure and a roentgenogram showed crushing fracture of the first lumbar vertebral body.

The case was reported on account of the failure to make an early diagnosis with the aid of roentgenograms.

The author concludes that the reason for this is the lack of marked persistent sensory or motor symptoms referable to cord injury and the patient's general condition being good.

Bone Grafts in the Repair of Defects of the Skull. (*Reparation des Breches Craniennes pat les Greffes Osseuses. Comparison avec les Greffes Cartalagineuses et avec l' Endoprothese*). P. MAUCLAIRE, Paris. *Paris Medical,* February 19, 1921.

The various methods of repair used in cases of skull wounds are classified as follows by the author:

I Living Bone
  a. From the neighborhood—periosteal, cutaneo-periosteal, osteo-periosteal
    1. With or without a pedicle
    2. Autoplastic, homoplastic, heteroplastic
  b. From a distance (tibia, etc.)

II Dead Bone (macerated, decalcified, carbonized calcinized, sterilized—homo- or heteroplastic)

The indication is always loss of bone substance without underlying cerebral lesion, the best results being obtained where this indication was fully met. For small defects, osteo-periosteal grafts taken from the neighborhood or from the tibia gave the best results. For large defects, broad pedunculated bone-diploë from the neighborhood gave the best results. Ivory or other endoprothesis may be of value with a small gap. Closing the wound has a markedly favorable effect psychically as well as objectively.

Recurring Dislocation of Shoulder Joint. JAMES WARREN SEVER, Boston. *The Journal of the American Medical Association,* April 2, 1921.

The deltoid and coracobrachialis will hold the head of the humerus in place if given a chance; and by removing the

pull of the stronger pectoralis major and taking up the slack in the stretched subscapularis, one can be assured of a permanent cure. The complete division of the pectoralis major, then, should be practiced in all cases without subsequent suture as well as definite shortening of the tendon of the subscapularis. These two procedures are essential. Repair of other torn or stretched tendons, such as the supraspinatus and infraspinatus, may also be made, but are not as necessary. Capsulorrhaphy may also be performed in conjunction with these two primary steps, but is not an essential to success. Complete division of the pectoralis major has been done by Sever in about forty cases with no untoward results. The arm can be adducted quite as well as before, and no essential loss of function has been observed.

Irreducible Dislocations of the Foot. (*Deux Cas de Luxations irreductibles du Pied*) M. WIART, Paris. *La Presse Medicale,* February 19, 1921.

The first case, a subastragaloid dislocation of the first degree according to Baumgartner—Hugeuer's classification, was apparently irreducible. The author performed an arthrotomy and then made an easy reduction. He believes that this method can almost always give reduction where other means fail, and that astragalectomy, formerly considered the method of choice, does not conserve function and has limited indications.

The second case was one of luxation of the internal plantar medio-tarsal joint. Here again reduction was impossible, and the author opened the space of Chopart and succeeded in replacing in good position the seaphoid and cuboid. But the reduction was not maintained so that several periarticular sutures had to be taken. After three weeks immobilization, the patient was up and around bearing full weight on the foot, with an excellent functional result. This type of dislocation is very rare.

Researches on Bone Grafts (*Recherches sur les Greffes Osseuses*). L. CHRISTOPHE, Liege. *La Presse Medicale,* March 12, 1921.

The author confirms the experimental work of Nageotte and Sencert in regard to the regeneration of grafts of dead tissue, using bone boiled for sterilization and preserved in alcohol, instead of the soft tissues they used—arteries, nerves, and tendons. Using this bone as grafts experimentally on rabbits and dogs, he found that in certain favorable cases, the bone showed definite evidences of regeneration and union with the adjacent living tissue so that on microscopy dead and living bone were not distinguishable. In less favorable cases this was not observed, however, even after a period of five and one-half months. Four pictures of sections illustrating the growth of this dead bone are shown. The author is following this work up, and intends to give full details and results in a later article.

Air Injection Into Joints and the Derangements of the Semilunar Cartilages (*Le Syndrome Meniscal et la Pneumosereuse Articulaire*). J. TERRACOL and L. J. COLANERI, Metz. *La Presse Medicale,* February 9, 1921.

The authors believe that insufflation of joints for radioscopic purposes at last offers the only certain means of diagnosing internal derangements of the knee. Using Bennet's classification of derangements of the semilunar cartilages, the authors experimentally produced similar pictures on the cadaver, followed by air injection and radiography.

After these experiments and after some practical experiences with some cases in which the diagnosis were checked by surgical intervention, the authors are certain that insufflation facilitates the study and differential diagnosis of the anatomico-physiological lesions composing the meniscal syndrome, especially the more frequent dislocation of the meniscus which has a characteristic picture in the radiogram which they compare to a "coup d'onde". It permits verification of clinical data and also aids in establishing the diagnosis. It is of great interest also for further investigation of exact localization for therapeutic purposes.

Book Reviews

Orthopedic Surgery. By ROYAL WHITMAN, M.D., M.R.C.S., Eng., F.A.C.S., Associate Surgeon to the Hospital for Ruptured and Crippled, New York; Orthopedic Surgeon to the Hospital of St. John's Guild; Consulting Orthopedic Surgeon to St. Agnes' Hospital for Crippled and Atypical Children, White Plains, etc. *Sixth Edition.* Royal Octavo; 914 pages; 767 illustrations. Philadelphia and New York: LEA & FEBIGER, 1920.

The sixth edition of this standard work differs from the fifth chiefly in the expansion of the chapter on Military Orthopedic (including Reconstruction) Surgery from 12 to 55 pages. This has been accomplished without materially enlarging the book, by a condensation of 30 pages in the rest of the text. Whitman lays stress on diagnosis and on the prevention of deformity, which makes his work a particularly valuable one as a guide for the general practitioner and the general surgeon.

A Manual of Surgery for Students and Physicians. By FRANCIS T. STEWART, M.D., Formerly Professor of Clinical Surgery, Jefferson Medical College; Surgeon to the Pennsylvania Hospital. *Fifth Edition.* Royal Octavo; 1086 pages; 590 illustrations. Philadelphia: P. BLAKISTON'S SON & Co, 1921.

This is a posthumous edition, the manuscript for which, almost finished by the author, was completed and prepared for publication by Dr. Walter Estell Lee. There are many changes and considerable amplification. As might be expected, these are found in the sections on infection and disinfection, shock, transfusion, fractures, amputations, and plastic operations. There is also much new matter in the sections dealing with the bones, the joints, the chest, the nerves, the rectum and the urinary tract. Much of the chapter on surgery of the abdomen has been rewritten.

The work is essentially a manual for the student and for the medical practitioner.

Traumatic Surgery. By JOHN J. MOORHEAD, B.S., M.D., F.A.C.S., Late Lt.-Col., Medical Corps, American Expeditionary Forces; Professor of Surgery and Director, Department of Traumatic Surgery, New York Post-Graduate Medical School and Hospital; Visiting Surgeon to Harlem Hospital; Attending Surgeon, Park Hospital; Consulting Surgeon, All Souls' Hospital (Morristown, N. J.); Lt.-Colonel, Medical Reserve Corps, U. S. Army. *Second Edition.* Royal Octavo; 864 pages; 619 illustrations. Philadelphia and London: W. B. SAUNDERS COMPANY, 1921.

Moorhead's work is a valuable contribution to the literature of a subject in which the surgical profession has recently manifested a much quickened enthusiasm, one in which the industries in general and the community at large are deeply interested.

The first edition appeared just before we entered the World War. Since then the author's very large experience in traumatic surgery has been greatly augmented by active service in base- and advanced-hospitals in France. This has been brought to bear in the preparation of the second edition, which is fully representative of those methods, developed during the war, that are equally useful in the treatment of injuries in civil life. The work has thus been expanded by about 100 pages, and enriched by about the same number of illustrations. There has also been added a chapter on Standardized First-Aid Treatment.

In extended critique of the first edition (The JOURNAL, October, 1917) we called attention to its many good features and criticised its faults of omission and of commission. Some of these are again apparent in the second edition. Skin-grafting is not adequately discussed for a work of this character. Hydrocele (scrotal) scarcely belongs in such a book for trauma is "the rarest of all causes", as Moorhead himself says. Traumatic hydrocele usually subsides spontaneously, and for the non-traumatic variety neither Jabou-

lays' operation nor Andrews', which, beside aspiration, are the only ones described, is the best. Concerning the first edition we said "He includes a reference to subacromial bursitis quite properly since this affection is probably traumatic in origin. His too-brief description and his indications for treatment are, however, quite misleading. He reproduces here the illustrations from Brickner's articles on this subject, but he has mislabeled them altogether, in effect misquoting this author". The reviewer is pained to find that in the second edition this section is reproduced without any correction. Nevertheless the reviewer recognizes in this work, especially in its now more comprehensive form, an excellent and practical exposition of traumatic surgery; and he recommends the book not merely to general practitioners but also to those experienced in surgery.

History and Bibliography of Anatomic Illustrations, in its Relation to Anatomic Science and the Graphic Arts. By LUDWIG CHOULANT. Translated and edited with notes and a biography by MORTIMER FRANK, B.S., M.D., Secretary, The Society of Medical History, Chicago. With a biographical sketch of the translater and two additional sections by FIELDING H. GARRISON, M.D., and EDWARD C. STREETER, M.D. Royal Octavo; 422 pages; illustrated. Chicago; THE UNIVERSITY OF CHICAGO PRESS. (for the Mortimer Frank Memorial Committee) 1920.

This volume is published as a memorial to Dr. Frank who died in 1919 soon after the completion of this edited translation.

Choulant's book is one of the classics of medical literature and stands alone as the only authoritative and comprehensive book of anatomical illustration extant. As only one edition was published in 1852 and as copies of this book are scarce, students of anatomic illustration will welcome Dr. Frank's translation. Frank, however, did more than a mere translation. By comparing this book with an original copy of Choulant, of which the reviewer is a proud possessor, one can see what immense labor Frank must have expended in bringing forth this work. The text has been amplified considerably; references to which Choulant had no access have been inserted and the whole has been brought thoroughly up to date. Indeed, to all intents and purposes this is a new book, only the nucleus of which is Choulant's famous work. All the original illustrations have been carefully reproduced and a large number of new ones added.

Garrison has contributed much to the charm and value of this book. In addition to a short sketch of Dr. Frank's career, he adds two chapters: one (with Dr. Streeter) on "Sculpture and Painting as Modes of Anatomical Illustration" and the second on "Anatomical Illustration since the Time of Choulant". Both are written with all this distinguished author's scholarliness and grace of style. This book is one of the noteworthy contributions to historical medical literature and will serve as an invaluable reference for many years to come. Any medical library will be graced by its presence.

Theophrastus Bombastus von Hohenheim, called **Paracelsus.** His Personality and Influence as Physician, Chemist, Reformer. By JOHN MAXSON STILLMAN, Professor of Chemistry Emeritus, University of California. Octavo; 184 pages, illustrated. London and Chicago: THE OPEN COURT PUBLISHING CO., 1920.

Paracelsus is one of the romantic figures in medicine. Although his life and works have been subjected to extensive historical research and criticism, it is difficult to gain a fair perspective of his influence upon medicine. By some he is regarded as little more than a charlatan, by others his influence is supposed to have been enormous. Unquestionably Paracelsus was a most picturesque character; a combination of charlatan, braggard, tramp, mystic blackguard, fighter; and yet withal an ironoclast, a doctor well versed in medical lore and possessed of unusual common sense, a chemist with knowledge far in advance of his time, and a man of absolutely fearless and independent mind. In an age when orthodoxy was the rule, he smashed traditions right and left, disagreed with the formulas of Galenic doctrine and fought with reckless abandon the views of his contemporaries. He erected a system of medicine of his own that was a remarkable combination of mysticism and shrewd insight. Amidst the immense rubbish of his writings, one finds some remarkable pronouncements and extraordinary intuitions. He was a pioneer in chemistry and helped greatly to release it from alchemy. He repeatedly insisted on the power of nature to heal disease; he dimly grasped the principle of asepsis; he realized the necessity of fighting the cause of disease rather than its symptoms, he conceived disease as a disharmony of normal functions, and he added many new facts to the nosology of various diseases.

Dr. Stillman has given us an excellent account of this extraordinary person; it is based largely upon the study of Paracelsus' genuine writings and upon the monumental researches of Sudhoff. His account has enabled us to gain a better perspective of the life of Paracelsus than that we have been enabled to obtain from any other source. The book has afforded us many moments of real pleasure.

Doederlein- Kroenig Operative Gynaekologie. *IV Auflage.* Bearbeitet von Dr. med. et Dr. art. obs. h. c. ALBERT DOEDERLEIN, Geheimer Hofrat, O. O. Professor der Geburtshilfe and Gynaekologie; Direktor der Universitäts-Frauenklinik, München. Imp. Octavo; 1028 seiten; 455 teils farbigen abbildungen und 15 farbigen tafeln. Leipzig: GEORG THIEME, 1921.

This volume has always been considered an authoritative exposition of the state of operative gynecology and abdominal surgery in Germany and Austria. A new edition after an interval of nearly nine years, is therefore well worthy of careful scrutiny.

Krönig, of Freiburg, one of the previous co-editors, died recently. Therefore the whole task of revision (except in the chapter dealing with anesthesia, where a young man, Zweifel, has helped) has fallen to Döderlein.

The new edition is larger by 74 pages and 26 illustrations than the previous one. The excellence of the illustrations is maintained.

Spinal (lumbar) anesthesia is still highly recommended and constantly employed. Statistics now embrace 42,754 cases with 47 deaths, or one death in 910 cases. To avoid accidents, only gold or platinum trocars are used, stovain is preferred, not more than 4 ccm. of fluid is injected (this includes the spinal fluid withdrawn), the specific gravity of the solution must be high, and the patient is kept in the sitting position for four minutes.

Extradural (para-sacral), parametrial and para-vertebral anesthesia are used by some. Local anesthesia is recommended solely for the repair of fresh perineal tears. Its use in laparotomy is inadvisable in most cases, post-operative pneumonia being *increased* where it is employed.

The floor drains of a modern operating room should be connected with the outlet of the sterilizers so that after each operation the water in the syphon traps is sterilized by the escaping steam. Thus no accumulation of septic matter can occur.

Physostigmin is no longer used post-operatively. Döderlein waits until flatus is passed before attempting to move the bowels.

No new methods for treating infection of the abdominal wound are mentioned.

Thrombosis and embolism can be reduced by not tying the legs when operating in the Trendelenburg position (use shoulder braces), by scrupulous hemostasis, by early graduated exercise in bed, and by giving heart stimulants for ten days after operation.

Among other operations for retroflexion of the uterus, Baldy's procedure is still recommended.

Hysterectomy is strongly condemned in the treatment of prolapse. The primary results are not lasting and the resulting enterocele can be cured only by complete obliteration of the vagina. The operations for cystocele have not been brought up to date by Döderlein.

The author has not much good to say for the interposition operation. He prefers the Schauta technic in which the uterus is covered by vaginal mucosa, to the method of Wertheim. As high a percentage of recurrences as 50, may be expected. A few operators are beginning to use fascial

transplants to help in holding the uterus and in strengthening the perineal floor.

After tying or resecting the tubes to induce sterility 6 per cent. of failures may be expected.

No change in the ultra-conservative treatment of genital and peritoneal tuberculosis appears.

Döderlein recommends immediate laparotomy in tubal pregnancy. He does not temporize in shock. In doubtful cases exploratory posterior colpotomy should be performed.

In patients over 40 years of age raying of fibroids is to be preferred to operation. Sarcoma is not a contraindication. On the contrary, the results here are far superior to operation. Corporeal cancer can be excluded by exploratory curettage.

The permanent (5 years) results with radium equal the operative cures although the radium cases were more advanced.

No changes in the operative technic for cancer of the cervix is recorded. Operation for recurrences are successful in only a small percentage of cases but this must be regarded as pure gain.

The closure of inguinal and femoral hernial sacs from within the abdomen is mentioned.

In intestinal surgery silk alone is used.

The advances in gastric surgery are not adequately discussed.

An undue amount of space and a wealth of new illustrations are accorded to the new operations (Sneguireff, Schubert, Strassmann) for forming a vagina by utilizing the rectum. The same criticism may be made of the description of Stoeckel's operation for establishing urinary continence by using the pyramidales muscles.

The recommendation for treatment of rectal prolapse is still limited to sigmoidopexy—which is not adequate.

No mention is made of fulguration in the treatment of bladder papillomata.

Hebosteotomy is still lauded.

Extraperitoneal Cesarian section is preferred to the transperitoneal operation.

These short abstracts give but a slight idea of the wealth of material dealt with. The volume, as before, is a monumental production, clear, concise, explicit—a safe and sane guide and a valuable councilor. It does, however, fail in showing many of the advances made, and is not as complete a revision as could be hoped for. For example, the time has arrived for again taking stock of the indications and prognosis for ovariotomy. Döderlein still uses the statistics of Pfannenstiel, etc., dating mainly from 1905. The reviewer had hoped that the wealth of material accumulated by the German clinics in the last 15 years would be sifted and presented to the profession.

The Sympathetic Nervous System in Disease. By W. LANGDON BROWN, M.A., M.D., (Cantab.), F.R.C.P. (Lond.) Physician with charge of Outpatients, St. Bartholomew's Hospital; Physician to the Metropolitan Hospital, etc. Duodecimo; 147 pages; 9 illustrations. London: HENRY FROWDE, HODDER & STOUGHTON, 1920.

An expansion of the Croonian lectures of 1918 has resulted in a most valuable volume dealing with the autonomic nervous system.

The interrelations of the involuntary nervous system to disease states are discussed only in relation to the endocrine glands, glycosuria, digestive disturbances, circulatory difficulties and vagatonia.

An introductory chapter is devoted to the plan of the autonomic nervous system, while a concluding section deals with the responses.

The needs for and the benefits of stimulation of the sympathetic and antagonistic parasympathetic systems in the struggle for existence are carefully presented and adequately serve as a preliminary basis for appreciating the functions of the unconscious mind. The value of the katabolic activities under control of the sympathetic system is briefly stressed with reference to the work of Cannon and Crile, but the surgeon will find more advantage in an understanding of the origin of local zones of hyperesthesia practically presented by Head.

The chapter dealing with the endocrine glands is logically developed, unusually clear and convincing, and reflects the complex but intimate interdependence of sympathetic function and endocrine activity in the interest of "the preservation of the individual and the continuity of the species." The adrenals, thyroid, and pituitary glands are considered in their relation to the autonomic nervous system.

The relation of the mind and emotions to the organic functions of the body is interpreted in terms of physiology and vital processes—beyond the control of the will, instead of in the terminology of the present day insistent psychologist.

The Croonian Lectures on **The Psychology of the Special Senses and Their Functional Disorders.** Delivered before the Royal College of Physicians in June 1920. By ARTHUR F. HURST, M.A., M.D. Oxon, F.R.C.P., Physician and Neurologist to Guy's Hospital. Octavo; 123 pages; illustrated. London: HENRY FROWDE; HODDER & STROUGHTON, 1920.

The Croonian Lectures, enriched by illustrative cases, present the views of the author on hysteria in its various manifestations. Its importance as an expression of symptoms induced by suggestion and curable by psychotherapy is not to be forgotten in connection with injuries of all types.

The frequency of hysterical states following surgical conditions suggests the value of familiarity with the simple problems as developed by the author in a convincing and satisfying manner.

Teeth and Health. How to Lengthen Life and Increase Happiness by Proper Care. By THOMAS J. RYAN, D.D.S. and EDWIN F. BOWERS, M.D. Duodecimo; 264 pages. New York and London: G. P. PUTNAM'S SONS. THE KNICKERBOCKER PRESS, 1921.

A popular disquisition on the importance of teeth as related to human health and happiness, written in the style of the medical columnist.

Books Received

Surgery. Its Principles and Practice. By various Authors. Edited by WILLIAM WILLIAMS KEEN, M.D., LL.D., Emeritus Professor of the Principles of Surgery and of Clinical Surgery, Jefferson Medical College, Philadelphia. *Volume VII.* Royal Octavo; 855 pages; 359 illustrations. Philadelphia and London: W. B. SAUNDERS COMPANY, 1921.

On Bone Formation, Its Relation to Tension and Pressure. By Dr. MURK JANSEN, O.B.E., Lecturer on Orthopedic Surgery, University of Leiden (Holland). Royal Octavo; 114 pages; illustrated. Manchester: THE UNIVERSITY PRESS. London, New York, Bombay, etc.: LONGMANS, GREEN & Co., 1920.

Operative Gynecology. By HARRY STURGEON CROSSEN, M.D., F.A.C.S., Associate in Gynecology, Washington University Medical School, and Associate Gynecologist to the Barnes Hospital; Gynecologist to St. Luke's Hospital, St. Louis Maternity Hospital, and Bethesda Hospital; Fellow of the American Gynecological Society and of the American Association of Obstetricians and Gynecologists. *Second Edition.* Royal Octavo; 717 pages; 834 illustrations. St. Louis: C. V. MOSBY COMPANY, 1920.

Clinical Surgery By Case Histories. By ARTHUR E. HERTZLER, M.D., PH.D., F.A.C.S., Professor of Surgery in the University of Kansas; Surgeon to the Halstead Hospital, Halstead, Kansas, and to St. Luke's and to St. Mary's Hospitals, Kansas City, Mo. *Volume I. Head, Neck, Thorax, and Extremities. Volume II. Diseases of the Abdominal and Genitourinary Organs.* Royal Octavo; 1106 pages; 483 illustrations. St. Louis: C. V. MOSBY COMPANY, 1921.